USAAVRADCOM-TR-80-D-38A

LEVEL III

(12)

AD A108246

ROTORCRAFT FLIGHT SIMULATION COMPUTER PROGRAM C81 WITH DATAMAP INTERFACE

Volume I — User's Manual

James R. Van Gaasbeek
BELL HELICOPTER TEXTRON
P. O. Box 482
Fort Worth, Tex. 76101

October 1981

Final Report for Period July 1979 — December 1979

Approved for public release; distribution unlimited.

Prepared for

APPLIED TECHNOLOGY LABORATORY
U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM)
Fort Eustis, Va. 23604

APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report documents an engineering analysis and resulting computer programs for the evaluation of rotary-wing aircraft performance, stability and control, rotor blade loads, maneuvering characteristics and rotor system aeroelastic stability through application of the model technique to the rotor blade equations of motion and stepwise integration of the time domain equations for the rotor, hub, aircraft and control system. Previous versions of the Rotorcraft Flight Simulation Computer Program, C81, have been used successfully to analyze a wide variety of rotorcraft configurations.

This version of C81, designated version AGAP80, was developed by adding some analytical features to the AGAJ76 version, and including the ability to generate Data Transfer Files for use by the File Creation Program of DATAMAP.

The project engineer for this contract was Mr. Donald J. Merkley, Aeromechanics Technical Area, Aeronautical Technology Division.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAAVRADCOM TR 80-D-38A	2. GOVT ACCESSION NO. AD-A1C 824	3. RECIPIENT'S CATALOG NUMBER 699-099-111
4. TITLE (and Subtitle) ROTORCRAFT FLIGHT SIMULATION COMPUTER PROGRAM C81 WITH DATAMAP INTERFACE, Volume I - User's Manual		5. TYPE OF REPORT & PERIOD COVERED Final Report, July 1979 - December 1979 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) James R. Van Gaasbeek		8. CONTRACT OR GRANT NUMBER(s) DAAK51-79-C-0015
9. PERFORMING ORGANIZATION NAME AND ADDRESS Bell Helicopter Textron P. O. Box 482 Fort Worth, Texas 76101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 612209 1L162209AH76 00 265 ~~EK~~
11. CONTROLLING OFFICE NAME AND ADDRESS Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM) Fort Eustis, Virginia 23604		12. REPORT DATE October 1981 13. NUMBER OF PAGES 574
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Volume I of a two-volume report

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aerodynamics	Flight Simulation	Dynamics
Aeroelasticity	Helicopters	Structural Properties
Rotors	Control	Stability
Computer Programs	Numerical Analysis	Wake Analysis
Digital Computers	Rotary Wing Aircraft	DATAMAP

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents the current version in the C81 family of rotorcraft flight simulation programs developed by Bell Helicopter Textron. This current version of the digital computer program is referred to as AGAP80. The accompanying program for calculating fully-coupled rotor blade mode shapes is called DNAM05, and an associated rotor wake program is called AR9102.

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Continued

The AGAP80 version of C81 was developed by adding some analytical features to the AGAJ76 version, and including the ability to generate Data Transfer Files for use by the File Creation Program of DATAMAP.

An overview of the computer program capabilities and the principal mathematical models incorporated in the program are given in Volume I of the documentation for the AGAJ76 version of the program.

Volume I, the User's Manual, contains the detailed information necessary for setting up an input data deck and interpreting the computed data. Volume II, the Programmer's Manual, includes a catalog of subroutines and a discussion of programming considerations. The source tapes and related software for the computer programs documented in this report are unpublished data on file at the Applied Technology Laboratory, U. S. Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia.

PREFACE

This report and its accompanying computer program were developed under Contract DAAK51-79-C-0015, awarded in 1979 by the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM). This report supersedes all previous versions of the program and documentation, including USAAMRDL-TR-76-41A, B, C and USARTL-TR-77-54A, B and C.

Technical program direction for the C81 aspects of the project was provided by Messrs. E. E. Austin and D. J. Merkley of the Applied Technology Laboratory. The authors also wish to thank Mr. John Davis of the Aeromechanics Laboratory for his many helpful suggestions. The principal Bell Helicopter personnel associated with the C81 portion of the current contract were Messrs. J. R. Van Gaasbeek and P. Y. Hsieh.

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Concluded

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS - Continued

LIST OF ILLUSTRATIONS - Continued

LIST OF ILLUSTRATIONS - Continued

LIST OF ILLUSTRATIONS - Concluded

LIST OF TABLES

LIST OF TABLES - Concluded

1. INTRODUCTION

The purposes of this volume of the report are to inform the reader of the capabilities of the current version of the Rotorcraft Flight Simulation Program C81 and to provide the information necessary for assembling an input data deck and successfully executing the program. The previous version of the program (Reference 1) has been improved by providing the capability to generate Postprocessing Data Blocks containing selected variables during quasi-static and time-variant trim. These data sets can be postprocessed either by the C81 postprocessor, GDAP80, or by the DATAMAP[2] program. A contour plot option has been included in GDAP80.

This version of the program, designated AGAP80, is capable of modeling the following components of a rotorcraft: a fuselage; two rotors, each with a modal pylon, aeroelastic blades, and a nacelle; a wing; four stabilizing surfaces, none of which must be purely vertical or horizontal; four external stores or aerodynamic brakes; a nonlinear, coupled control system including a collective bobweight, stability and control augmentation system, and maneuver autopilot simulator; two jets; and a weapon.

The nine sections following this introduction present only the information required to set up and successfully execute a C81 simulation. The reader is referred to Volume I of Reference 1 for documentation of the programmed mathematical models and to Volume II of this report for information regarding the computer program hardware requirements and available software.

Sections 2 and 3 of this report list the input data for the analysis program, AGAP80, and the postprocessing program, GDAP80, in a sequence that corresponds to the input and card sequence required for the data deck. The inputs are grouped according to either their function in the program or the rotorcraft component they simulate. For example, three of the AGAP80 input groups are the Program Logic Group, the Main

[1]McLarty, T. T., et al., ROTORCRAFT FLIGHT SIMULATION WITH COUPLED ROTOR AEROELASTIC STABILITY ANALYSIS, Volumes I-III, Bell Helicopter Textron, USAAMRDL Technical Reports 76-41A, 76-41B, 76-41C, Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1977, AD A042462, AD A042908, AD A042907.

[2]Philbrick, R. D., and Eubanks, A. L., OPERATIONAL LOADS SURVEY - DATA MANAGEMENT SYSTEM, Volumes I and II, USARTL TR 78-52A, -52B, Applied Technology Laboratory, U.S. Army Research and Technology Laboratories, Fort Eustis, Virginia, 1979, AD A065129, AD A065270.

Rotor Group, and the Wing Group. Each group is read into an array whose name is given in all uppercase letters at the left of the input sequence numbers in Section 2. Except for the first letter, the array names were chosen to be abbreviated acronyms for the title of the group or component. As an aid to the user and the programmer, a special convention was established for the first letter of each array: arrays beginning with the letter I control program logic; arrays beginning with Y contain the inputs used in the equations that compute the aerodynamic forces on the rotor blades, fuselage, wing, and stabilizing surface; arrays beginning with T contain times that are used during maneuvers; and arrays beginning with X contain, for the most part, inputs that are physically measurable quantities, e.g., locations, weights, angles, lengths, and control linkages.

Where possible, the definition of each input is a brief, one-line description, with the required units, if any, given in parentheses at the right end of the line. However, some inputs cannot be defined so concisely. In some of these cases, the FORTRAN symbol assigned to the input in the program is listed. The symbol is generally an acronym for the input, which will have meaning to the experienced user of the program.

In all cases where a FORTRAN array or variable name is used, the standard FORTRAN convention for the format of the input applies. That is, if the first letter of an array or symbol is I, J, K, L, M, or N, the corresponding input must be a fixed point number (integer), i.e., "I" format. All fixed-point inputs must end in the rightmost column of the field for the input and must not contain a decimal point.

If the first letter of the variable name is not one of the six listed above, the input must be a floating point (decimal) number, i.e., "F" format. Due to the form of the floating point formats used in C81, all such inputs should include a decimal point. If the decimal point is omitted, it is assumed to be at the far right end of the field. For example, if the number 1 is punched in the first column of a 10-column field and the decimal point is omitted, the number will be interpreted as 1000000000.0 rather than the 1.0 intended. Note that IBM FORTRAN allows the user to place an "E" format input in an "F" format field.

There are several inputs to the postprocessor program (GDAP80) that are "A" format. Any alphabetic or numeric character can be input in such a field.

Sections 2 and 3 are designed to be the only documentation that a very experienced user needs to set up an input deck. The less-experienced user should consult Sections 4 and 5 for a

more complete explanation of the inputs, setup of the deck, and program options. These sections are arranged in the same order as Sections 2 and 3 and include many of the equations used in the various mathematical models.

Sections 6 and 7 provide information on the output of the two programs. The first major subsection in Section 6 discusses the sign conventions in the program, including definitions of the reference systems used, and can be useful in setting up the deck as well as in interpreting the output. The remainder of Sections 6 and 7 explain each group of output which the programs can generate during a successful execution. The vast majority of the groups are output on the printer. This printed output falls into three general categories: input, trim, and maneuver data. In addition, most of the trim and maneuver data can be output on a CALCOMP plotter or transferred to the DATAMAP Master File. Examples of all possible groups of output data were taken from actual computer runs and are included in the section.

Section 8 lists and discusses the error messages that can be generated during a run. Some of the errors terminate program execution, while others are only warnings of conditions that may affect the data being computed. In each case, the source of the error is noted and, where necessary, a suggestion on how to correct the error is given. Section 9 lists the variables that are saved for future analysis during the computations of trims and maneuvers.

Utilization instructions for three ancillary programs, DNAM05, AR9102 and AN9101, are presented in Section 10. These programs create Rotor Elastic Blade Data (DNAM05), Rotor-Induced Velocity Distribution Tables (AR9102), and C81 fuselage inputs from test data (AN9101).

In this document, the rotors are referred to as Rotor 1 and Rotor 2. In the output, additional names, which are appropriate to the rotorcraft configuration, are used. All rotor names fall into two groups:

(1) Rotor 1, First, Main, Right, Forward

(2) Rotor 2, Second, Tail, Left, Aft

The names within a group may be considered synonymous, with context determining the appropriate word. The groups also indicate the input groups that should be used for a specific rotor. For example, inputs for the forward rotor of a tandem-rotor configuration should be input to the Rotor 1 Group and the aft rotor inputs to the Rotor 2 Group. However, this input sequence is not mandatory. (The program does not verify that

Rotor 1 is actually forward or to the right of Rotor 2.) With careful attention to the rotor control linkages, the two rotor groups can be swapped to reverse the direction of rotation of each rotor. See Section 4.30 for additional details.

1.1 AGAP80 OPERATIONS

The general operations of which the AGAP80 version is capable are:

(1) Compute a trimmed flight condition

(2) Perform a rotorcraft stability analysis

(3) Perform parameter sweeps of trim conditions, with or without a rotorcraft stability analysis

(4) Compute a maneuver with or without a rotorcraft stability analysis

(5) Retrieve maneuver time-history data stored on magnetic tape

These five operations are illustrated in the flow charts given in Figures 1 through 8. The block labelled "OPERATIONS ON TIME-HISTORY DATA" represents the execution of the postprocessing program, GDAP80.

Each of the AGAP80 operations or combination of operations is controlled by input data. Thus, the flow charts for the primary operations all begin with a "Read Data Deck" block. Since the amount of data to be read depends on the operation or operations desired, a data deck in this context consists of a message card, an "NPART" card telling the program which primary operation or operations to perform, and the additional data necessary to perform the indicated operation(s). In some cases, the additional data are contained on 500 or more additional cards, while in other cases, as little as one card of additional data is required for the AGAP80 input deck.

As implied by Figures 1 through 8, data decks of primary operations other than parameter sweeps cannot be stacked one after the other; each deck must be submitted as a separate computer job. This situation does not impose any significant hardship on the user, since

(1) the parameter sweep operation can be used to replace stacked trim-only (TRIM) and trim-and-stability-analysis (TRIM-STAB) decks, and

(2) in practice, the need to run more than one maneuver in a single job rarely, if ever, occurs.

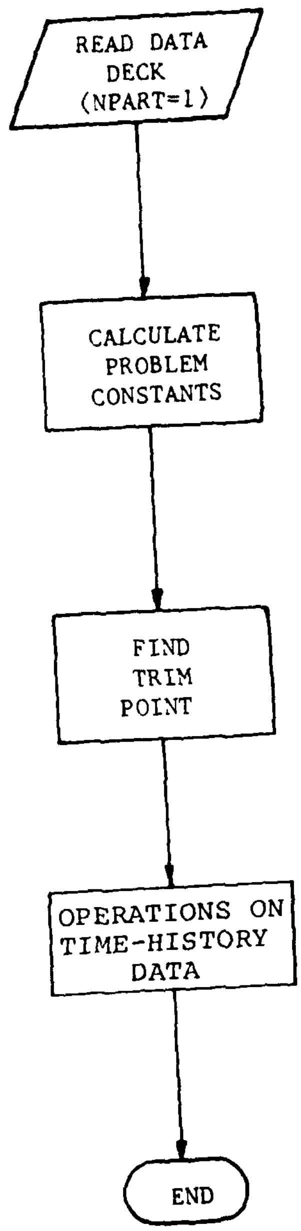


Figure 1. Trim-Only Operation.

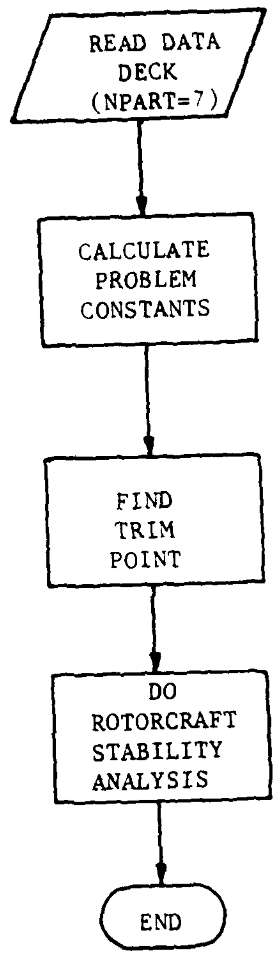


Figure 2. Trim and Rotorcraft Stability Analysis.

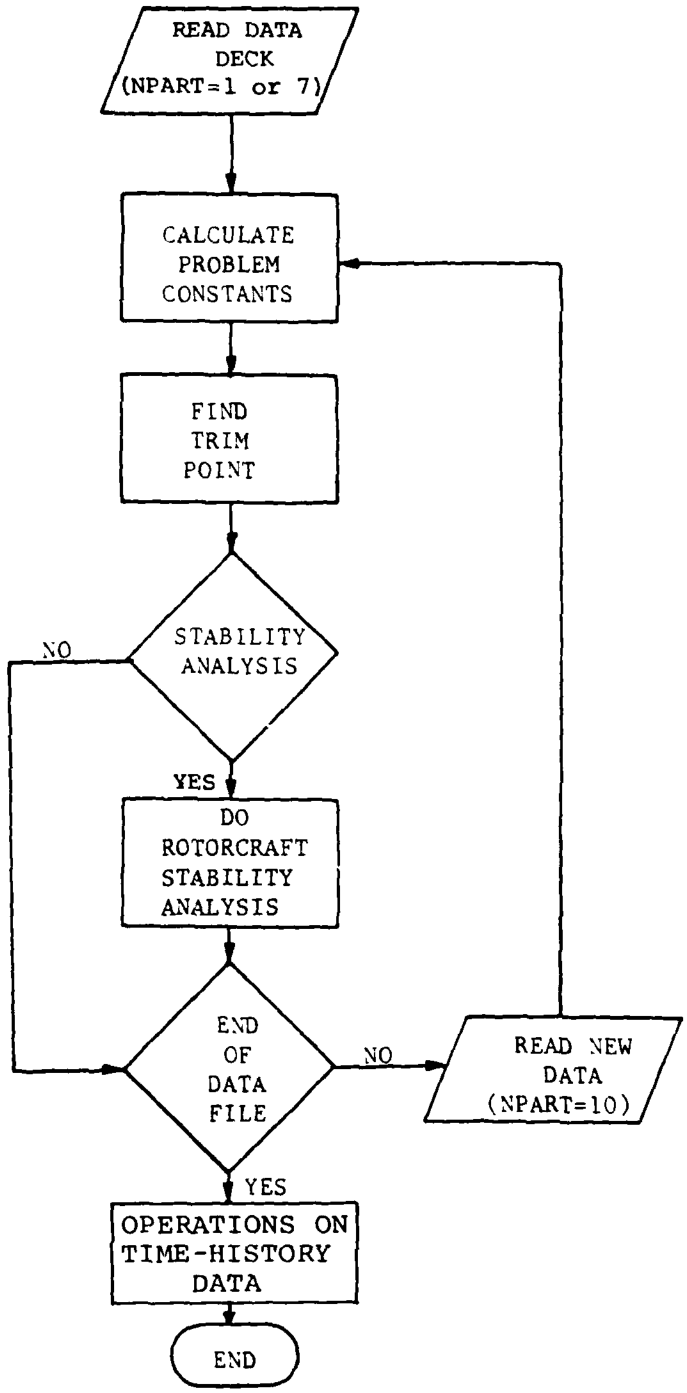


Figure 3. Trim or Trim and Rotorcraft Stability Analysis Followed by Parameter Sweep.

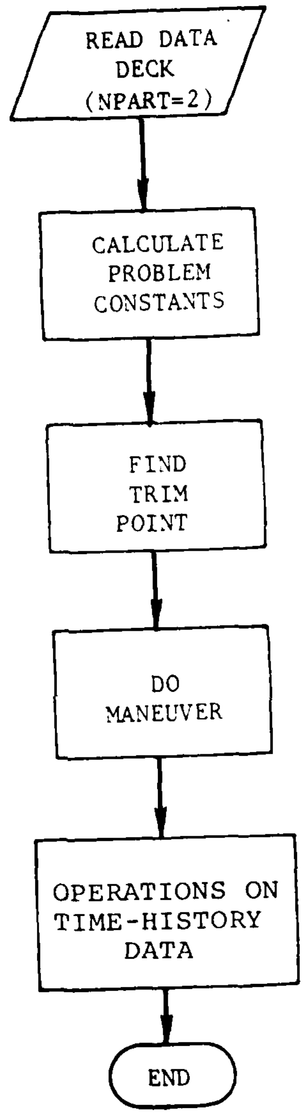


Figure 4. Trim Followed by Maneuver.

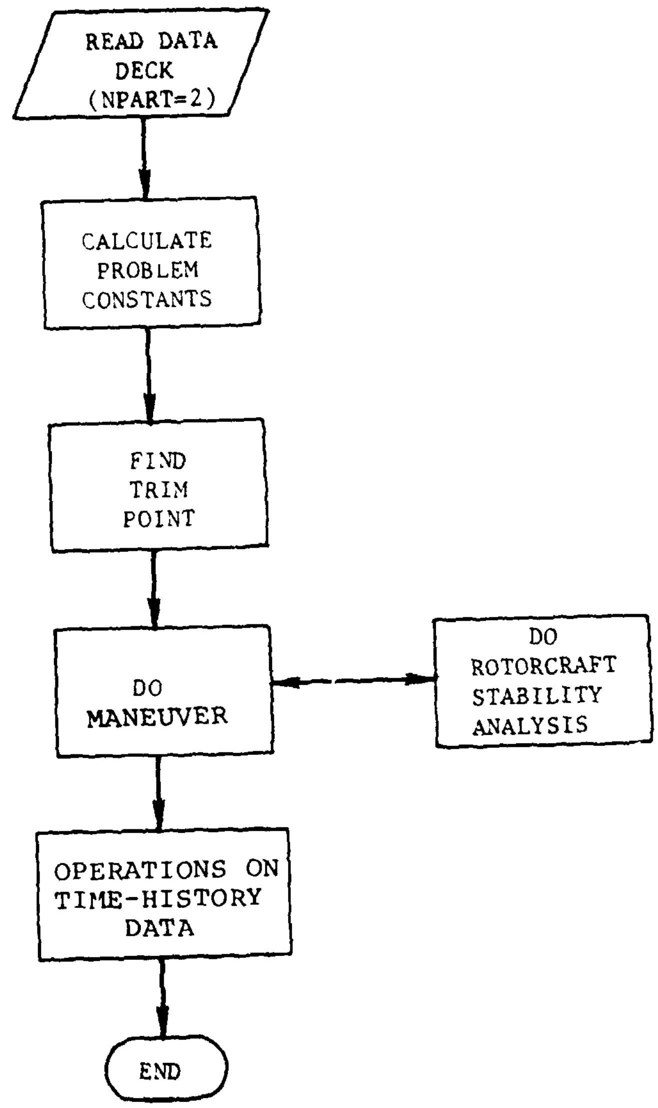


Figure 5. Trim Followed by Maneuver with Rotorcraft Stability Analysis.

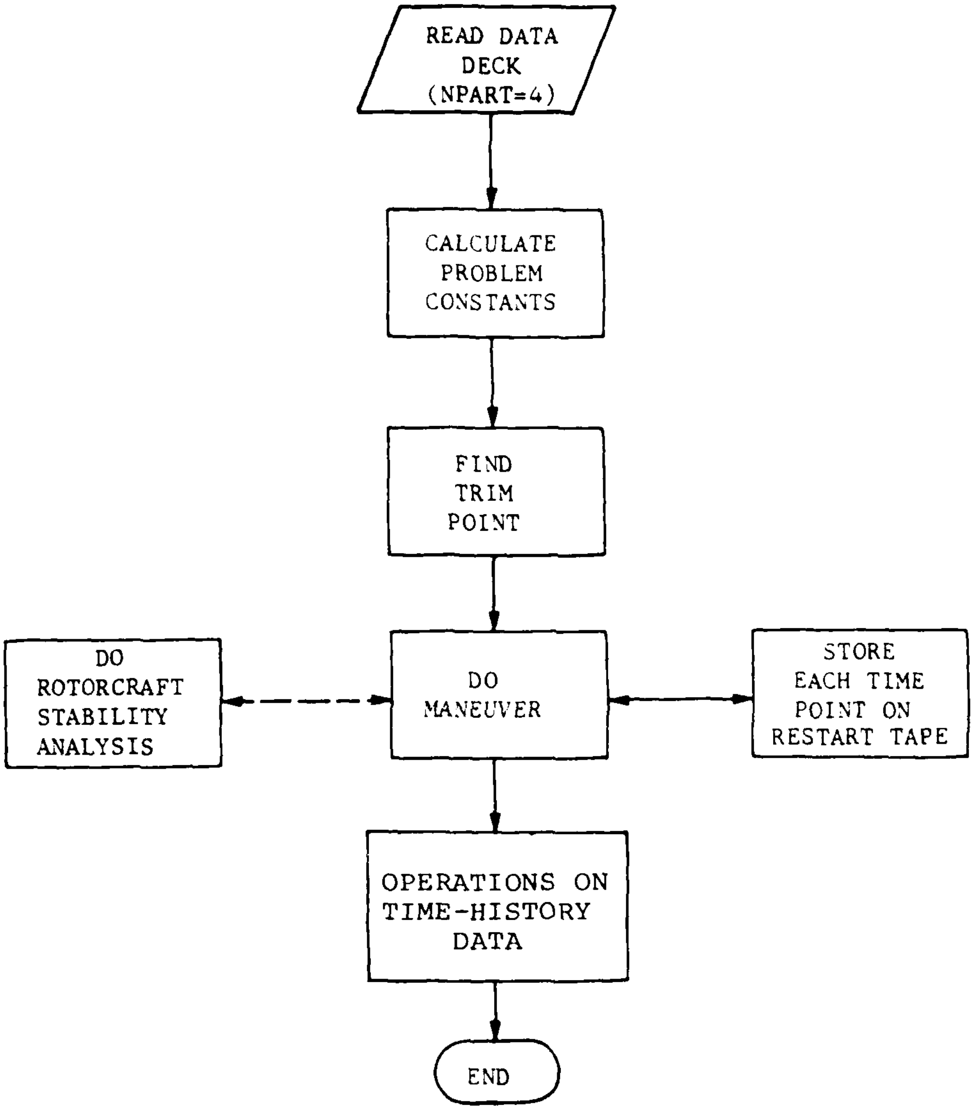


Figure 6. First Maneuver in Restart Procedure.

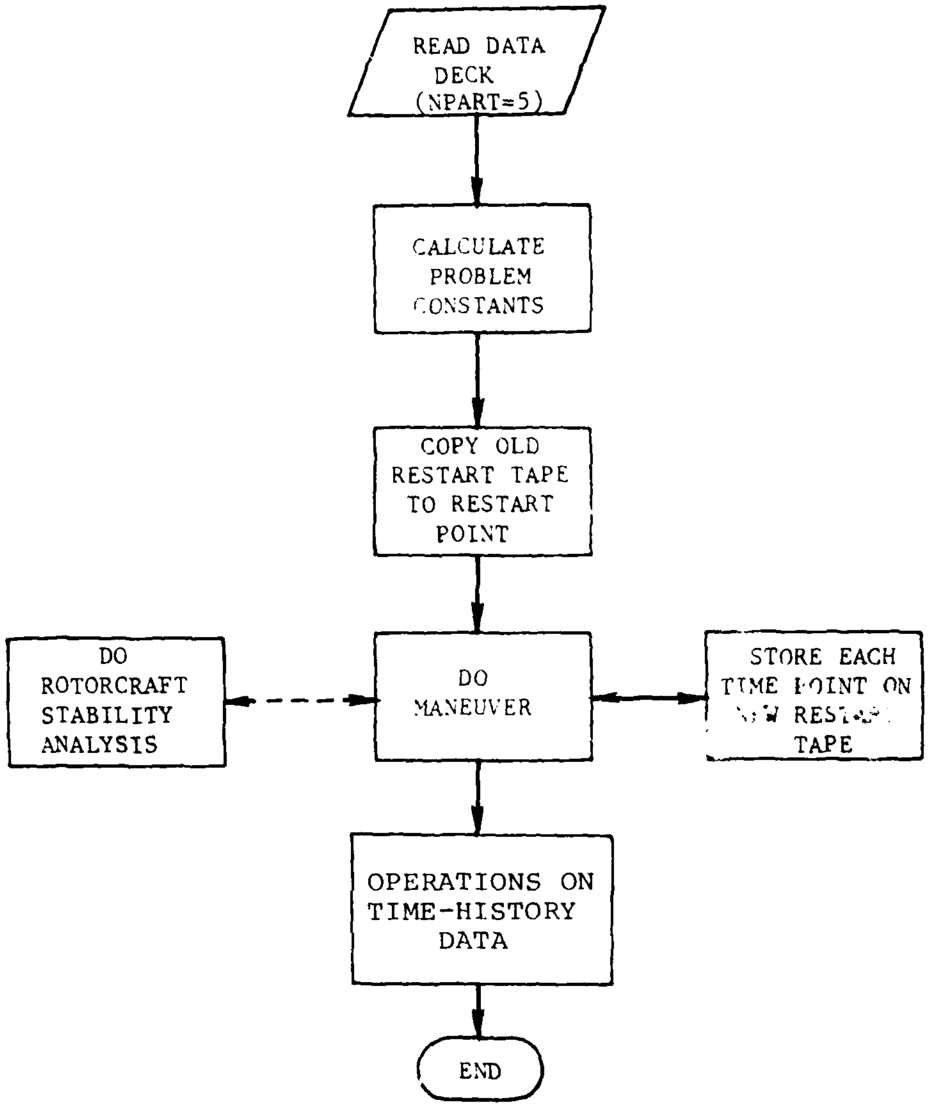


Figure 7. Second and Later Restart Maneuvers.

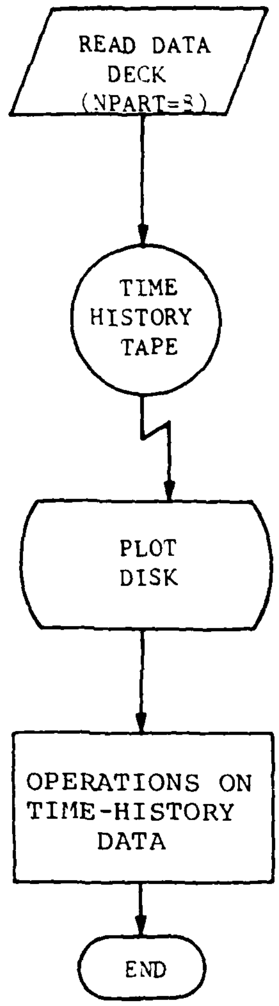


Figure 8. Retrieving Maneuver Data Stored Permanently.

The second step in several of the flow charts is "Calculate Problem Constants." In each operation containing this step, a number of quantities which remain constant throughout the performance of the operation(s) must be defined using the input data. For example, the density ratio is computed from the input pressure altitude and temperature and the length of the blade segments for a rotor are computed from the radius distribution. Performing such computations drastically reduces the number of program inputs and also provides program flexibility necessary for incorporating such operations as parameter sweeping.

1.1.1 Trimmed Flight (Figure 1)

In finding the trim point, the program iterates on the control positions, fuselage orientation, rotor attitude and/or engine power to reach desired values of the rotor flapping moments, forces and moments on the aircraft center of gravity and/or engine horsepower. When these desired values are achieved the rotorcraft is trimmed. With controls locked and no external disturbances such as gusts, the rotorcraft would theoretically continue indefinitely along the flight path prescribed by the program inputs.

The program also permits the calculation of two steady but accelerated flight conditions. In one, the rotorcraft is in a pushover or pullup condition at an input g-level. In the other, the rotorcraft is in a banked turn, either level or spiral, at an input g-level. In these cases, the desired net forces and moments on the rotorcraft are not all zero, but depend on the user-requested g-level. Either an unaccelerated or steady accelerated flight condition may be used as the starting point of a maneuver simulation.

1.1.2 Rotorcraft Stability Analysis (Figure 2)

Data for a trim point or a maneuver time point define the initial conditions for the rotorcraft stbility analysis operation. This option in the program is used to compute stability and control derivatives, evaluate the coefficients of the linearized rotorcraft equations of motion, solve the linearized equations for roots and mode shapes, compute the coefficients of the transfer functions for the rotorcraft, and calculate the frequency response of the transfer functions.

1.1.3 Trim Sweeps (Figure 3)

The parameter sweep operation may be used to simulate the stacking of TRIM and TRIM-STAB data decks for a given rotorcraft. Within a sweep deck, the user specifies by input data those cases in the sweep for which a rotorcraft stability

analysis is and is not to be performed. The parameters most frequently swept include airspeed, gross weight, center-of-gravity station-line, incidence of an aerodynamic surface, atmospheric conditions, and g-level. Generally, only one parameter is changed from case to case within a single sweep deck. However, any number and combination of inputs except some program logic switches and the values in some data tables may be swept. The assumption is made that each desired trim condition bears some relationship to the previous one, and that the previous trim point is a good starting condition for finding the next trim point. For example, in a speed sweep, a change of 20 or 30 knots is the most that should normally be used between 40 and 150 knots. Outside of this range, the maximum change should not exceed 10 knots.

1.1.4 Maneuver Simulation (Figure 4 through 7)

The trim analysis is automatically invoked whenever a maneuver simulation is requested. The trim point data are used to supply the initial conditions to a system of differential equations that describe the behavior of the rotorcraft in a maneuver. Various external inputs, or forcing functions, may be applied, such as control movements, gusts, store drops, and wing incidence change independent of control motion(s). At times specified by input data, the maneuver can be suspended while a rotorcraft or rotor aeroelastic stability analysis is performed. The maneuver is then resumed as if no interruption had occurred and continued until it reaches either the next time point to do a stability analysis or the end of the maneuver.

A maneuver restart operation is begun just like an ordinary maneuver using a trim condition as a starting point. The only difference is that the time-history variables and many intermediate variables are saved on the restart magnetic tape. Subsequent maneuver restarts use the condition at one of the saved time points as the initial conditions, and so do not require a trim condition or the complete data set defining the rotorcraft.

1.1.5 Retrieving Maneuver Time History Data Stored on Magnetic Tape (Figure 8)

A small portion of AGAP80 is invoked to read a maneuver data tape that had been created during a previous maneuver simulation. The data read from the tape is transferred to a disk file for subsequent postprocessing by GDAP80.

1.2 GDAP80 OPERATIONS

During the course of running a trim or maneuver, the values of a large number of time-history variables at each time point are

saved on the plot disk. At the conclusion of the trim or maneuver, postprocessing operations specified in the GDAP80 input data are performed on these variables. The available operations are shown in Figure 9.

1.2.1 Time-History Plots (Figure 10)

The user may request time-history plots of any of the variables saved during trim or maneuver simulations. These plots may be output on the printer, a CALCOMP drum plotter, or both. Plots created as part of a maneuver restart run will contain data for the entire maneuver.

1.2.2 Aeroelastic Stability Analyses (Figures 11 and 12)

Program GDAP80 contains two analyses capable of identifying the frequency and damping of a perturbed multi-variable system. The user can select either the Moving Block Fast Fourier Transform Analysis (NPART=6) or the Prony Analysis (NPART=13) to examine the nonsteady-state response of either rotor. The frequency and damping characteristics of airframe motion may also be investigated using these analyses, but that is not their primary function.

1.2.3 Storing Time-History Data on Tape (Figure 13)

If it is desired to perform additional postprocessing of the saved variables, they may be transferred from the plot disk to a magnetic time-history tape. The data on the tape may then be reloaded to the plot disk for further use at a later time.

1.2.4 Harmonic Analysis (Figure 14)

A complete harmonic analysis may also be made for any of the saved variables. A Fast-Fourier-Transform technique is used to examine a broad range of frequencies. This option is especially useful for studying rotor bending moments and related variables.

1.2.5 Vector Analysis (Figure 15)

Frequently, maneuvers are run where one of the controls or the longitudinal mast tilt angle is varied sinusoidally. In this case, the vector analysis operation can be very useful. This analysis uses the least-squared-errors technique to fit the saved data to a curve of the form

$$F_i(t) = A_i \sin(\omega t + \phi_i) + B_i \tag{1}$$

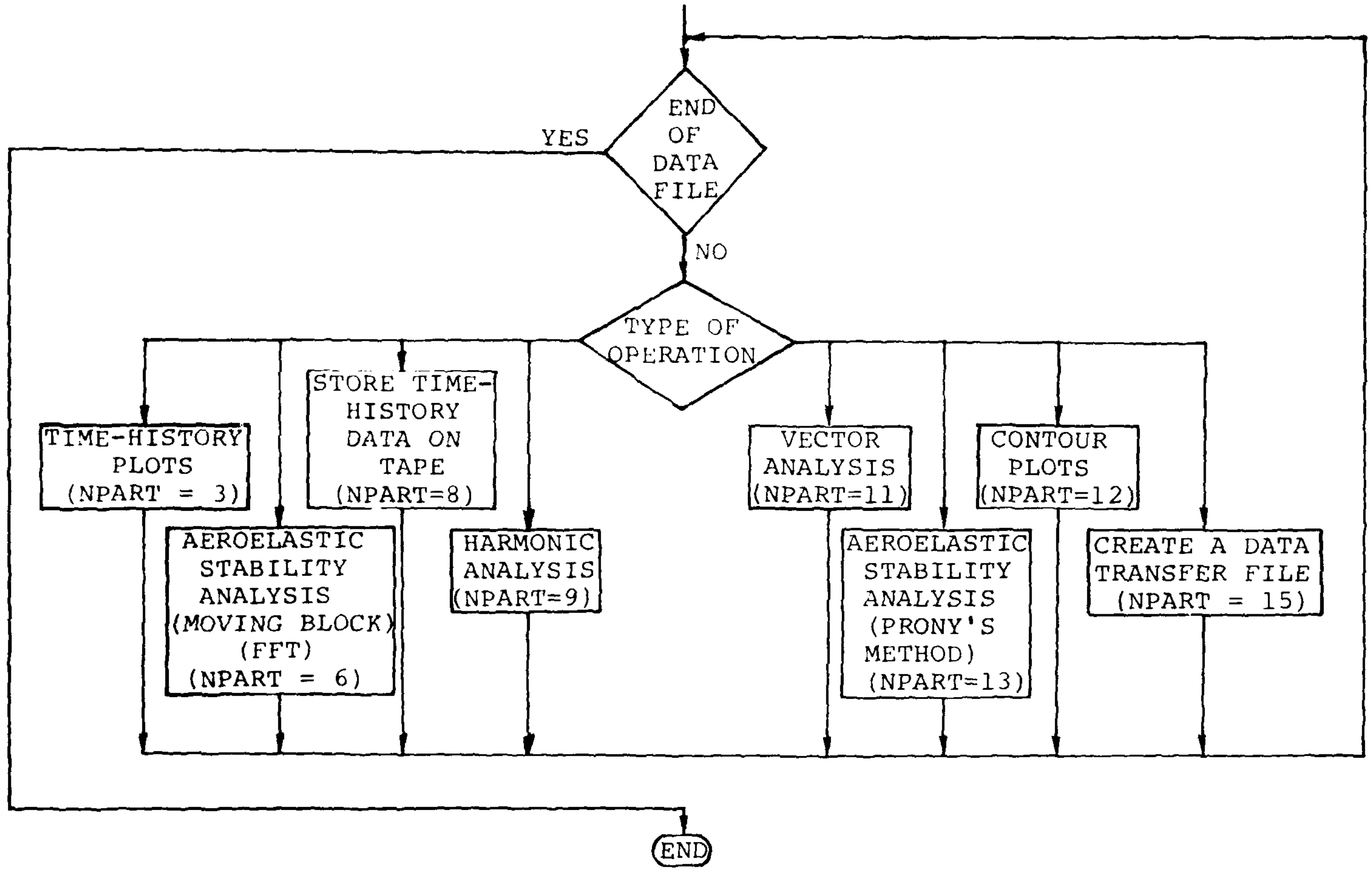


Figure 9. Block for Operations Performed on Time-History Data.

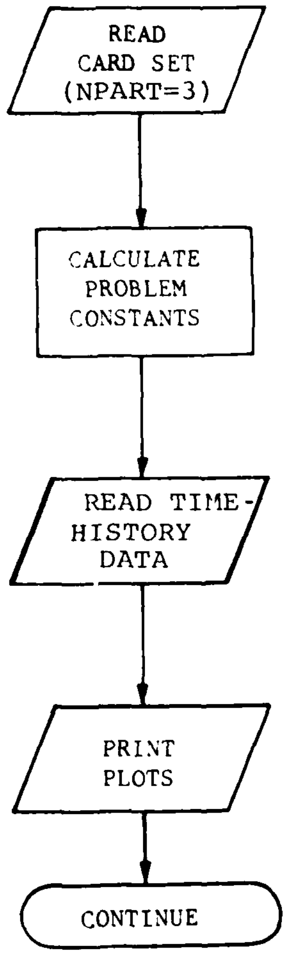


Figure 10. Plotting Operation.

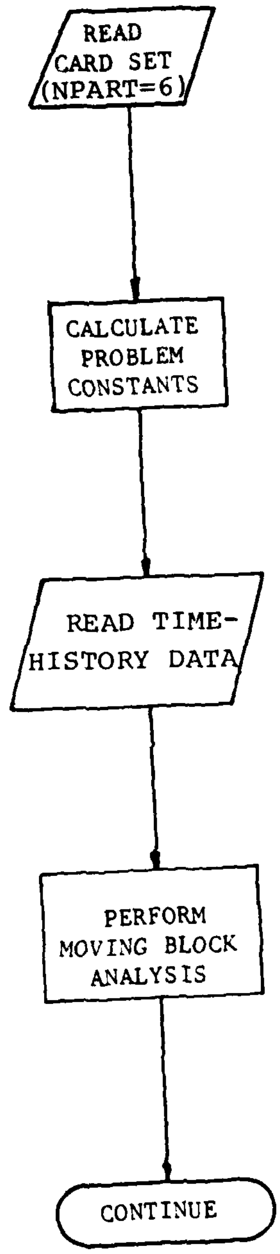


Figure 11. Moving Block Fast-Fourier-Transform Operation.

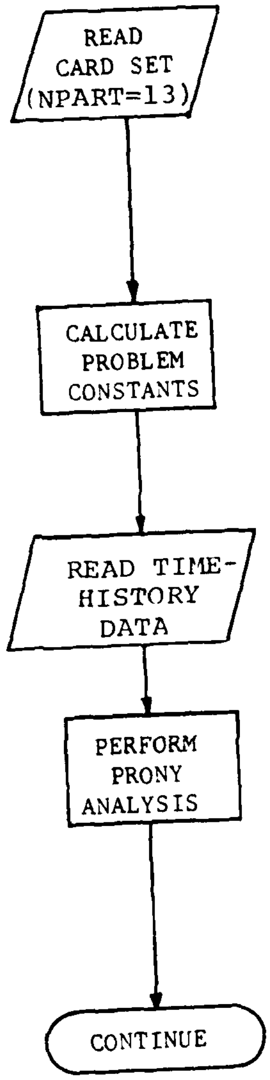


Figure 12. Prony Stability Analysis Operation.

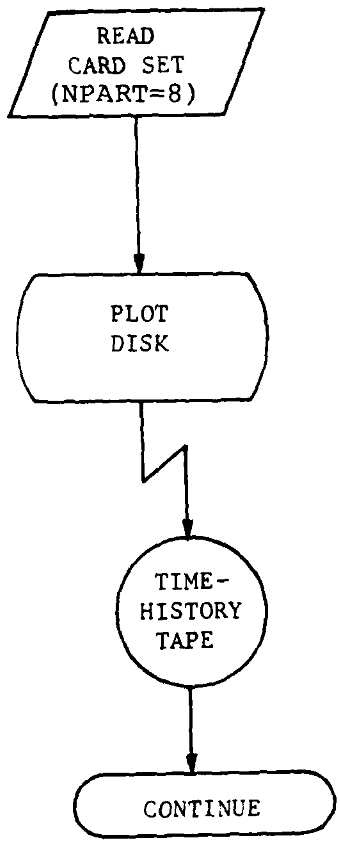


Figure 13. Operation for Storing Time-History Data on Tape.

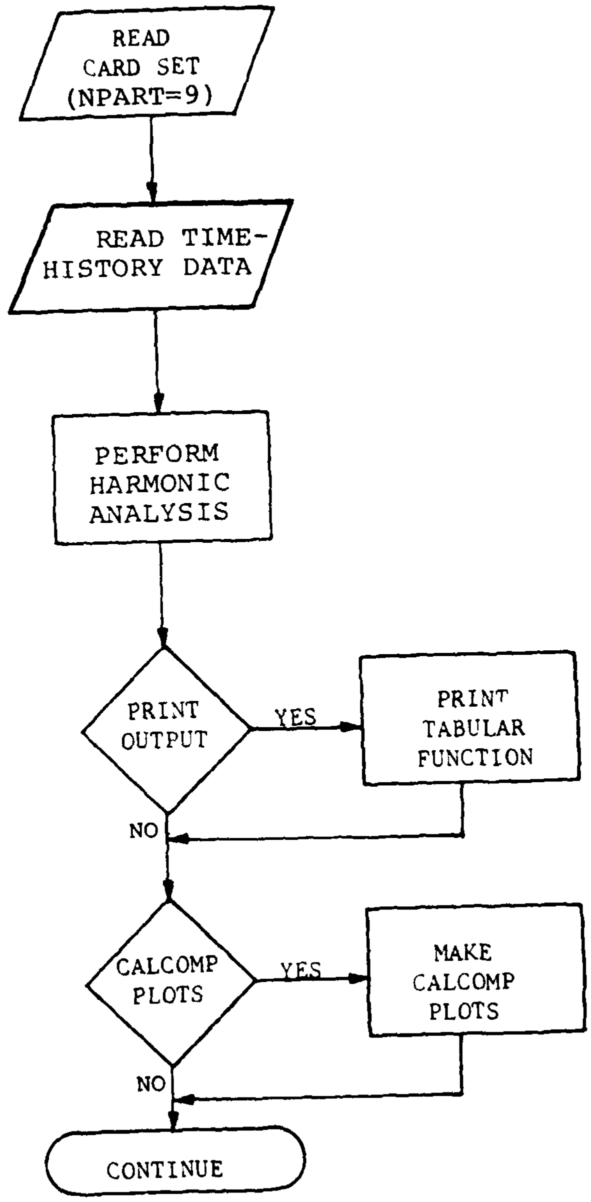


Figure 14. Harmonic Analysis Operation.

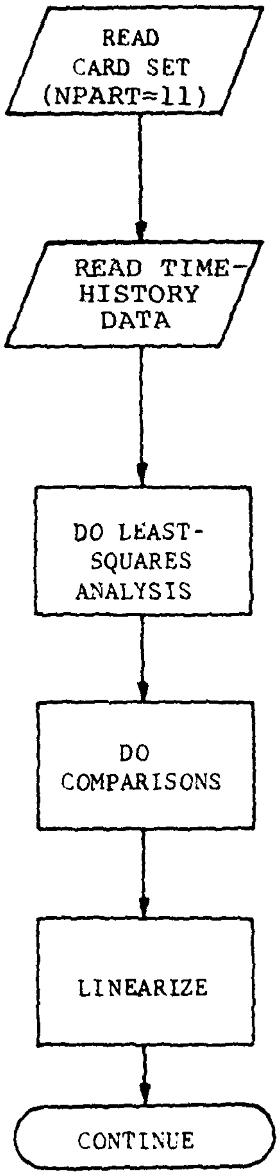


Figure 15. Vector Analysis and Data Reduction Operation.

Then, any amplitude ratios, A_i/A_j, and phase angle differences, $\phi_i - \phi_j$, may be computed. Lastly, linear combinations of the variables may be derived in the following form:

$$F_i(t) = C_i\ F_j(t) + D_i\ F_k(t) + E_i \qquad (2)$$

1.2.6 Contour Plots (Figure 16)

Rotor aerodynamic quantities can be tabulated versus radial station and azimuth and plotted in plane-polar format using this option. The data are plotted assuming that the blade stations are equally spaced along the radius - no radial interpolation is performed. The tabulations and plots are particularly useful for displaying the rotor aerodynamic environment.

1.2.7 Creating a Data Transfer File (Figure 17)

This option permits the user to transmit C81-generated data to a temporary file accessed by the DATAMAP File Creation program in order to add the data to the DATAMAP Master File. The user can then use DATAMAP to postprocess the C81 data and compare it with test data also resident upon the master file.

1.3 PROGRAMMING AND DOCUMENTATION CONSIDERATIONS

A great deal of effort has been expended to make the programs as user-oriented as possible. Most of the switches controlling the different AGAP80 options have been included in the Program Logic Group. The user can therefore determine the nature of the model and the analysis to be used by checking the inputs on the seven cards of this group.

Also, the documentation of the input format (Sections 2 and 3) and the user's guide to the input format (Sections 4 and 5) have been written to make the definition of the inputs as clear and specific as possible. The definitions are not all easy to understand because of the nature of some of the variables, but the definitions presented usually leave room for only one interpretation. A sample set of input data for a typical attack helicopter is included in Section 6 along with a detailed discussion of the program output so that the user can get an idea of the magnitude of most program inputs and outputs.

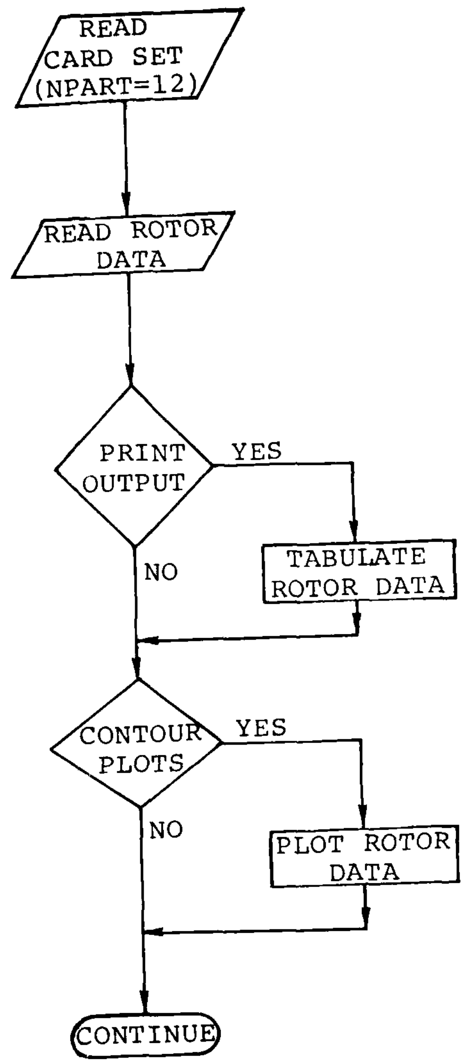


Figure 16. Contour Plot Operation.

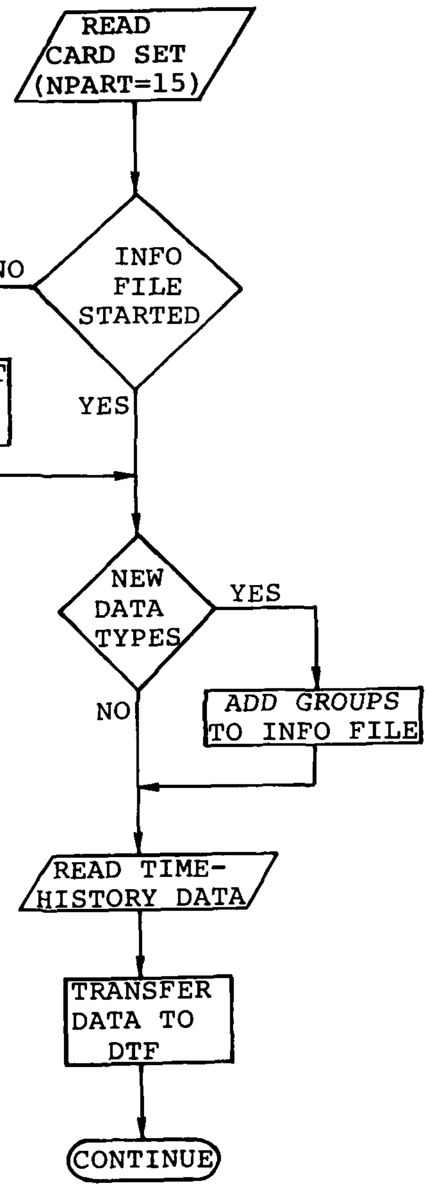


Figure 17. Creation of a Data Transfer File.

2. INPUT FORMAT FOR AGAP80

This section of the report presents the basic input format for an AGAP80 card deck. The first subsection contains general information regarding the structure of, and program features related to, the card deck. The remaining subsections define the inputs to each of the basic input groups to the program. The groups are described in the same sequence in which they occur in the data deck.

For the very experienced user of C81, Section 2 is frequently the only documentation that is needed to set up, execute, and make changes to an AGAP80 data deck. When more explanation is required, the user should consult Section 4 which is arranged in the same order as Section 2 and includes detailed discussions of input definitions, program options, and many of the equations used in the program.

2.1 GENERAL

2.1.1 Composition of a Data Deck and Card Format

A complete input data deck for AGAP80 can be divided into the 52 groups or sets of cards listed in Table 1. The first 44 groups form the basic card deck, which is used for trim-only and trim-and-rotorcraft-stability-analysis-only program operations. The remaining eight groups are only included in the deck when a maneuver is to be simulated.

The Program Logic Group is one of the most important groups in the deck. It controls which groups must be included in the deck and the program options that will be used in the computations. The input format for this group is 14 integer inputs per card with five column fields for each input (14I5 format). A primary reason for the integer format is to set the group apart from the remainder of the deck, in which the vast majority of the inputs are floating point numbers.

Except for the Program Logic Group, a standard format of seven floating point numbers in 10 column fields per card (7F10.0 format) is used wherever practical in the deck. Only the exceptions to this standard format are noted in the following sections. Where the format cannot be conveniently expressed by a FORTRAN statement like 7F10.0, the location of the input on the card is specified by the column or field of columns for the input. Unless otherwise noted, all formats start in Column 1, with Columns 71 through 80 reserved for a card sequence number.

TABLE 1. SEQUENTIAL SUMMARY OF INPUT GROUPS

Group Title	Sequence Number of ID Card *	Element Number in MODEL Data Set Array **	Section
Deck Identification & Program Flow Control Cards	None	N/A	2.2
Program Logic Group	10	1	2.3
Airfoil Data Table Group	None	N/A	2.4
Airfoil Data Table No. 1	21	2	2.4.1
Airfoil Data Table No. 2	22	3	2.4.1
Airfoil Data Table No. 3	23	4	2.4.1
Airfoil Data Table No. 4	24	5	2.4.1
Airfoil Data Table No. 5	25	6	2.4.1
Airfoil Data Table No. 6	26	7	2.4.1
Airfoil Data Table No. 7	27	8	2.4.1
Airfoil Data Table No. 8	28	9	2.4.1
Airfoil Data Table No. 9	29	10	2.4.1
Airfoil Data Table No. 10	2A	11	2.4.1
Rotor 1 Group	30	12	2.5
Rotor 1 Elastic Pylon Group	40	13	2.6
Rotor 1 Elastic Blade Data Group	50	14	2.7
Rotor 2 Group	60	15	2.8
Rotor 2 Elastic Pylon Group	70	16	2.9
Rotor 2 Elastic Blade Data Group	80	17	2.10
Rotor Aerodynamic Group	90	18	2.11
Rotor 1 Rotor-Induced Velocity Distribution (RIVD) Table	100	19	2.12.1
Rotor 2 RIVD Table	110	20	2.12.2
Rotor-Wake-at-Aerodynamic-Surface (RWAS) Table Group	None	N/A	2.13
RWAS Table No. 1	***	21	2.13
RWAS Table No. 2	***	22	2.13
RWAS Table No. 3	***	23	2.13

TABLE 1. (Continued)

Group Title	Sequence Number of ID Card *	Element Number in MODEL Data Set Array **	Section
RWAS Table No. 4	***	24	2.13
RWAS Table No. 5	***	25	2.13
RWAS Table No. 6	***	26	2.13
RWAS Table No. 7	***	27	2.13
RWAS Table No. 8	***	28	2.13
RWAS Table No. 9	***	29	2.13
RWAS Table No. 10	***	30	2.13
RWAS Table No. 11	***	31	2.13
RWAS Table No. 12	***	32	2.13
Basic Fuselage Group	120	33	2.14
Fuselage Aerodynamic Group or Fuselage Aerodynamic Table	130	34	2.15
Wing Group	140	35	2.16
Stabilizing Surface Groups	None	N/A	2.17
Stabilizing Surface No. 1	150	36	2.17.1
Stabilizing Surface No. 2	160	37	2.17.2
Stabilizing Surface No. 3	170	38	2.17.3
Stabilizing Surface No. 4	180	39	2.17.4
Jet Group	190	40	2.18
External Store/Aerodynamic Brake Group	200	41	2.19
Rotor Controls Group	210	42	2.20
Iteration Logic Group	220	43	2.21
Flight Constants Group	230	44	2.22
Bobweight Group	240	45	2.23
Weapons Group	250	46	2.24
SCAS Group	260	47	2.25
Stability Analysis Times Group	270	48	2.26
Blade Element Data Printout Times Group	280	49	2.27
Maneuver Time Card	None	N/A	2.28

TABLE 1. (Continued)

Group Title	Sequence Number of ID Card *	Element Number in MODEL Data Set Array **	Section
Maneuver Specification Cards	None	N/A	2.29
Maneuver Analysis Cards	None	N/A	2.30→ 2.36

*"None" indicates that the group does not have an identification (ID) card.

**"N/A" indicates that the group is not included in the MODEL data set array.

***No specific sequence number on RWAS Table ID Cards.

2.1.2 Group Identification Cards and Analytical Data Base

The input groups which include a Group Identification (ID) Card are noted in Table 1 by the inclusion of a sequence number for the ID card.

The format for each of these ID cards is as follows:

Field	Description of the Input
Col 1→8	IDEN, Analytical Data Base name for the group
Col 11→70	Alphanumeric identifying comments (optional)
Col 71→80	Card sequence numbers (optional)

If the user's version of AGAP80 does not include the Analytical Data Base Option, Columns 1 through 8 (IDEN) must be blank. If this option is included, IDEN may be used to call the required inputs for the corresponding group from the Analytical Data Base. If MODEL Option data sets are stored in the data base, IDEN on CARD 10 (Program Logic Group ID Card) may be used to call a complete set of groups from the Analytical Data Base.

Input data which are called from the Analytical Data Base and whose array name is included in Table 2 can be updated with the &CHANGE program feature. When the MODEL Option is used, the &GROUPS program feature can be used to replace entire groups in the MODEL Option data set by reference to the element number given in Table 1. Figure 18 shows an example MODEL Option data deck with the &CHANGE and &GROUPS features employed. See Section 4.1.2 for a complete discussion of the Analytical Data Base and MODEL Options. See Section 4.1.3 for explanation of the &CHANGE and &GROUPS program features.

2.1.3 Input Data Changes Compared to AGAJ76 Version

The last published documentation for C81 was for version AGAJ76, Reference 1. In Sections 2.2 to 2.28, changes in individual input data items introduced in the AGAP80 version of the program are noted by an asterisk (*) along the right-hand margin of the page. Where a major change has been made, a footnote is used to describe the change.

TABLE 2. INPUT DATA ARRAYS INCLUDED IN NAMELIST SPECIFICATION STATEMENT

Array Name and Range of Subscripts	Description of Array
IPL(1→98)	Program Logic Group
XMR(1→56)	Rotor 1 Group
XMBS(1→20)	Rotor 1 Blade Station Distribution
XMACF(1→20)	Rotor 1 Airfoil Aerodynamic Reference Center Distribution
XMC(1→20)	Rotor 1 Chord Distribution
XMT(1→20)	Rotor 1 Twist Distribution
XMDI(1→28)	Rotor 1 Harmonic Blade Shaker and Harmonic Control Motion
IDTABM(1→20)	Rotor 1 Airfoil Distribution
XMP(1→140)	Rotor 1 Dynamic Pylon
XMW(1→105)	Rotor 1 Weight & Inertial Distribution
XGMS(1→18, 1→12)	Blade General Mode Shape Data
XTR(1→56)	Rotor 2 Group
XTBS(1→20)	Rotor 2 Blade Station Distribution
XTACF(1→20)	Rotor 2 Airfoil Aerodynamic Reference Center Distribution
XTC(1→20)	Rotor 2 Chord Distribution
XTT(1→20)	Rotor 2 Twist Distribution
XTDI(1→28)	Rotor 2 Harmonic Blade Shaker and Harmonic Control Motion
IDTABT(1→20)	Rotor 2 Airfoil Distribution
XTP(1→140)	Rotor 2 Dynamic Pylon

TABLE 2. (Continued)

Array Name and Ranges of Subscripts	Description of Array
XTW(1→105)	Rotor 2 Weight & Inertial Distribution
YRR(1→35,1)	RAA Subgroup No. 1
YRR(1→35,2)	RAA Subgroup No. 2
YRR(1→35,3)	RAA Subgroup No. 3
YRR(1→35,4)	RAA Subgroup No. 4
YRR(1→35,5)	RAA Subgroup No. 5
YRR(1→35,6)	RAA Subgroup No. 6
YRR(1→35,7)	RAA Subgroup No. 7
YRR(1→35,8)	RAA Subgroup No. 8
YRR(1→35,9)	RAA Subgroup No. 9
YRR(1→35,10)	RAA Subgroup No. 10
XFS(1→35)	Basic Fuselage Group
YFS(1→70)	Fuselage Aerodynamic Group
XWG(1→42)	Wing Group (Basic)
YWG(1→28)	Wing Aerodynamics
XCWG(1→14)	Wing Control Linkages
XSTB1(1→35)	Stabilizing Surface No. 1 Group (Basic)
YSTB1(1→28)	Surface No. 1 Aerodynamics
XCS1(1→14)	Surface No. 1 Control Linkages
XSTB2(1→35)	Stabilizing Surface No. 2 Group (Basic)
YSTB2(1→28)	Surface No. 2 Aerodynamics
XCS2(1→14)	Surface No. 2 Control Linkages
XSTB3(1→35)	Stabilizing Surface No. 3 Group (Basic)

TABLE 2. (Concluded)

Array Name and Range of Subscripts	Description of Array	
YSTB3(1→28)	Surface No. 3 Aerodynamics	
XCS3(1→14)	Surface No. 3 Control Linkages	
XSTB4(1→35)	Stabilizing Surface No. 4 Group (Basic)	
YSTB4(1→28)	Surface No. 4 Aerodynamics	
XCS4(1→14)	Surface No. 4 Control Linkages	
XJET(1→14)	Jet Group	
XST1(1→21)	Store/Brake No. 1	External Store/ Aerodynamic Brake Group
XST2(1→21)	Store/Brake No. 2	
XST3(1→21)	Store/Brake No. 3	
XST4(1→21)	Store/Brake No. 4	
XCON(1→28)	Rotor Controls Group (Basic)	
XCRT(1→28)	Supplementary Rotor Controls	
XIT(1→77)	Iteration Logic Group	
XFC(1→28)	Flight Constants Group	
XBW(1→7)	Bobweight Group	
XGN(1→7)	Weapons Group	
XSCAS(1→28)	SCAS Group	
TSTAB(1→14)	Stability Analysis Times Group	
TAIR(1→14)	Blade Element Data Printout Times Group	

The following sets of inputs are specifically excluded from the NAMELIST specification statement: All airfoil data tables, both mode shape arrays, both RIVD tables, and all RWAS tables.

```
1
  80051601 SAMPLE OPERATIONAL LOADS SURVEY FLIGHT TEST SIMULATION CASE
USING THE MODL OPTION OF AGAP80 FOR INCLUSION IN THE INPUT GUIDE
                                                     (PAN NAME C818MODL)
COUNTER 615. FLIGHT 35A
MODLOLSN
 &GROUPS MODEL(2)='CLCDVS12',MODEL(44)='                 ', &END
129.3       0.0       0.0       1000.0    -1.2      -3.2      -1.232
35.0        70.0      55.0      50.0
-2.0        -0.5      -1.1      1.0       7450.0    -250.0
0.0         0.0       1250.0    6600.0    -1.0      2900.0    27.0
 &CHANGE YFS(15 =5.5     &END
```

Figure 18. Example of Data Deck for MODEL Option.

2.2 IDENTIFICATION AND PROGRAM FLOW CONTROL GROUP

CARD 00 Message card. Columns 1-80, alphanumeric.

CARD 01 Col 1 - 2 NPART (permissible values are 1, 2, 4, 5, 7, 8, and 10)
Col 4 - 6 NPRINT
Col 11 - 15 NVARA

CARD 02 Col 4 - 10 IPSN
Col 11 - 70 Identifying Comments

CARD 03 Col 1 - 68 Identifying Comments

CARD 04 Col 1 - 68 Identifying Comments

2.3 PROGRAM LOGIC GROUP

CARD 10 Program Logic Group Identification Card

Col 11 - 70 Identifying Comments

CARD 11 Input Group Control Logic (14I5 format)

IPL
(1) Trim Logic Switch (0 through 11) *
(2) Number of Airfoil Data Tables (0 through 10) *
(3) Switch for deleting rotor groups (0 = include both rotor groups)
(4) Number of Rotor 1 blade segments ($\geq$0, uniform; 0 reset to 20)
(5) Number of Rotor 2 blade segments ($\geq$0, uniform; 0 reset to 3)
(6) Number of Rotor 1 mode shapes $\leq$11 } Total
(7) Number of Rotor 2 mode shapes $\leq$11 } $\leq$12
(8) Currently unused
(9) Number of Rotor 1 elastic pylon modes ($\leq$10; >0, full rotor mass included; <0, no rotor mass included) *
(10) Number of Rotor 2 elastic pylon modes (same as for IPL(9)) *
(11) Number of Rotor Airfoil Aerodynamic Subgroups (0 through 10) *
(12) Switch for reading Rotor-Induced Velocity Distribution Tables (0 = off)
(13) Switch for reading Rotor Wake Tables (0 = off)
(14) Switch for harmonic blade shaker and harmonic control motion (0 = off) *

CARD 12 Input Group Control Logic (14I5 format)

IPL
(15) Switch for reading Wing Group (0 = off)
(16) Switch for reading Stabilizing Surface #1 Group
(17) Switch for reading Stabilizing Surface #2 Group
(18) Switch for reading Stabilizing Surface #3 Group
(19) Switch for reading Stabilizing Surface #4 Group
(20) Switch for reading Jet Group (0 = off)
(21) Number of Store/Brake subgroups (= 0, 1, 2, 3, or 4)
(22) Switch for reading Supplemental Rotor Controls subgroup (0 = off)
(23) Switch for reading maneuver input groups (0 = off)
(24)
(25) Currently unused *
(26)
(27) Rotor fold indicator (0 = unfolded)
(28) Switch for shifting cg with rotor folding (0 = no shift)

CARD 13

IPL
(29) Fuselage Aerodynamics Switch *
(30)
↓ Currently unused
(42)

CARD 14 Analysis Logic (14I5 format)

IPL
(43) Currently unused *
(44) Euler angle iteration selector for TRIM (0 = holds yaw angle constant)
(45) Switch for computing partial derivative matrix (0 = every fifth iteration)
(46) Control variable for Rotor 1 steady state aerodynamics
(47) Control variable for Rotor 2 steady state aerodynamics
(48) Switch for activating unsteady rotor aerodynamic options (0 = off)
(49) Switch for specifying which rotor can use the time-variant (TV) analysis (0 = none; both rotors use quasi-static (QS) analysis)
(50) Switch for activating TV analysis in TRIM and MANU when IPL(49) $\neq$ 0 (0 = QS trim followed by TV trim and maneuver)

(51) Control variable for rebalancing Rotor 1 in TRIM (0 = off; >0 locks flapping; <0 locks cyclic)
(52) Control variable for rebalancing Rotor 2 in TRIM (0 = off; >0 locks flapping; <0 locks cyclic)
(53)
(54) } Currently unused
(55) Switch for Wagner function (0 = off)
(56) Switch for locking fuselage degrees of freedom in maneuver (0 = unlocked)

CARD 15 Currently unused

IPL
(57)
(58) } Currently unused
(59)
(60) Switch to decouple Rotor 1 in Partial Derivative Matrix calculations *
(61) Switch to decouple Rotor 2 in Partial Derivative Matrix calculations *
(62)
↓ } Currently unused
(70)

CARD 16 Output Control Logic (14I5 format)

IPL
(71) Print control for input data (0 = print all input data)
(72) Print control for trim iteration data (0 = minimum output)
(73) Print control for optional trim page (0 = page omitted)
(74) Print control for Force and Moment Summary in wind-axis *
(75) Print control for Rotor 1 blade element aerodynamic data
(76) Print control for Rotor 2 blade element aerodynamic data
(77) Station number for Rotor 1 bending moment data
(78) Station number for Rotor 2 bending moment data
(79) Switch for storing contour plot data in QS trim (0 = off) *
(80)
(81)
(82) } Currently unused
(83)
(84) Print control for Time-Variant Trim data ($\neq$ 0 suppresses printout)

CARD 17 Rotorcraft Stability Analysis and Miscellaneous Logic (14I5 format)

IPL

(85) Switch for fuselage coupling in STAB (0 = uncoupled)

(86) Switch for pylon degrees of freedom in STAB (0 = off)

(87) Switch for rotor degrees of freedom in STAB (0 = off)

(88) Switch for rebalancing rotors in STAB when IPL(87) = 0 (0 = rebalance)

(89) Output control for STAB matrices (0 = print only)

(90) Output selector for STAB diagnostics (0 = off)

(91), (92) Currently unused *

(93) STAB numerators logic switch *

(94) Switch to suppress force and moment summary output from perturbations (≠ 0 suppresses) *

(95), (96), (97), (98) Currently unused

2.4 AIRFOIL DATA TABLE GROUP

This group does not have an all-inclusive group identification card (which would logically be CARD 20); each set of tables has its own.

2.4.1 Airfoil Data Table Set No. 1 (include only if IPL(2)≥1)

CARD 21   Table Identification Card

CARD 21/A Title and Control Card (7A4, A2, 6I2 format)

Col 1-30 Alphanumeric title for the table

31-32 NXL, number of Mach number entries in C_L subtable

33-34 NZL, number of angle of attack entries in C_L subtable

35-36 NXD, number of Mach number entries in C_D subtable

37-38 NZD, number of angle of attack entries in C_D subtable

39-40 NXM, number of Mach number entries in C_M subtable

41-42 NZM, number of angle of attack entries in C_M subtable

2.4.1.1 Lift Coefficient Subtable

CARD 21/B1 Mach number entries for C_L table (7X, 9F7.0 format)

Col 8-14 M_1, lowest Mach number

15-21 M_2, next highest Mach number

22-28 M_3, next highest Mach number

29-35 M_4, next highest Mach number

36-42 M_5, next highest Mach number

43-49 M_6, next highest Mach number

50-56 M_7, next highest Mach number

57-63 M_8, next highest Mach number

64-70 M_9, next highest Mach number

CARDS 21/B2 Additional Mach Numbers (include only if NXL ≥10)

Same format as CARD 21/B1; include additional cards as required with the same format to input NXL values of Mach numbers

Card Sets for Angle of Attack/Lift Coefficient Data

NZL card sets follow the Mach number entries. Each set has the following format:

First Card:

Col	1- 7	Angle of attack, degrees
	8-14	Coefficient at $M = M_1$
	15-21	Coefficient at $M = M_2$
	22-28	Coefficient at $M = M_3$
	29-35	Coefficient at $M = M_4$
	36-42	Coefficient at $M = M_5$
	43-49	Coefficient at $M = M_6$
	50-56	Coefficient at $M = M_7$
	57-63	Coefficient at $M = M_8$
	64-70	Coefficient at $M = M_9$

Second Card: (include only if NZL $\geq$10)

Col	1- 7	(Not used)
	8-14	Coefficient at $M = M_{10}$
	15-21	Coefficient at $M = M_{11}$
	22-28	Coefficient at $M = M_{12}$
	29-35	Coefficient at $M = M_{13}$
	36-42	Coefficient at $M = M_{14}$
	43-49	Coefficient at $M = M_{15}$
	50-56	Coefficient at $M = M_{16}$
	57-63	Coefficient at $M = M_{17}$
	64-70	Coefficient at $M = M_{18}$

Third Card: (include only if NZL $\geq$19)

Same format as Second Card; include additional cards as required to input NXL values of C_L.

2.4.1.2 Drag Coefficient Subtable

CARDS 21/C1, 21/C2, etc. Mach number entries

Same format as CARDS 21/B1, 21/B2, etc; NXD entries required.

Card Sets for Angle of Attack/Drag Coefficient Data

NZD card sets required; same format as for lift coefficient card sets; NXD values of C_D required for each card set.

2.4.1.3 Pitching Moment Coefficient Subtable

CARDS 21/D1, 21/D2, etc.

Same format as lift and drag coefficient subtables; NXM Mach number entries required; NZM card sets required with NXM values of C_M for each card set.

2.4.2 Airfoil Data Table Set No. 2 (include only if IPL(2) $\geq$2)

CARD 22	Table Identification Card
CARD 22/A	Title and Control Card
CARDS 22/B1	Lift Coefficient Subtable
CARDS 22/C1	Drag Coefficient Subtable
CARDS 22/D1	Pitching Moment Coefficient Subtable

2.4.3 Airfoil Data Table Set No. 3 (include only if IPL(2) $\geq$3)

CARD 23	Table Identification Card
CARD 23/A	Title and Control Card
CARDS 23/B1	Lift Coefficient Subtable
CARDS 23/C1	Drag Coefficient Subtable
CARDS 23/D1	Pitching Moment Coefficient Subtable

2.4.4 Airfoil Data Table Set No. 4 (include only if IPL(2) $\geq$4)

CARD 24	Table Identification Card
CARD 24/A	Title and Control Card
CARDS 24/B1	Lift Coefficient Subtable
CARDS 24/C1	Drag Coefficient Subtable
CARDS 24/D1	Pitching Moment Coefficient Subtable

2.4.5 Airfoil Data Table Set No. 5 (include only if IPL(2) $\geq$ 5)

CARD 25	Table Identification Card
CARD 25/A	Title and Control Card
CARDS 25/B1	Lift Coefficient Subtable
CARDS 25/C1	Drag Coefficient Subtable
CARDS 25/D1	Pitching Moment Coefficient Subtable

2.4.6 Airfoil Data Table Set No. 6 (include only if IPL(2) $\geq$ 6) +

CARD 26	Table Identification Card
CARD 26/A	Title and Control Card
CARDS 26/B1	Lift Coefficient Subtable
CARDS 26/C1	Drag Coefficient Subtable
CARDS 26/D1	Pitching Moment Coefficient Subtable

2.4.7 Airfoil Data Table Set No. 7 (include only if IPL(2) $\geq$ 7) +

CARD 27	Table Identification Card
CARD 27/A	Title and Control Card
CARDS 27/B1	Lift Coefficient Subtable
CARDS 27/C1	Drag Coefficient Subtable
CARDS 27/D1	Pitching Moment Coefficient Subtable

2.4.8 Airfoil Data Table Set No. 8 (include only if IPL(2) $\geq$ 8) +

CARD 28	Table Identification Card
CARD 28/A	Title and Control Card
CARDS 28/B1	Lift Coefficient Subtable
CARDS 28/C1	Drag Coefficient Subtable
CARDS 28/D1	Pitching Moment Coefficient Subtable

+ Additional tables

2.4.9 Airfoil Data Table Set No. 9 (include only if IPL(2) $\geq$ 9) +

CARD 29	Table Identification Card
CARD 29/A	Title and Control Card
CARDS 29/B1	Lift Coefficient Subtable
CARDS 29/C1	Drag Coefficient Subtable
CARDS 29/D1	Pitching Moment Coefficient Subtable

2.4.10 Airfoil Data Table Set No. 10 (include only if IPL(2) = 10) +

CARD 2A	Table Identification Card
CARD 2A/A	Title and Control Card
CARDS 2A/B1	Lift Coefficient Subtable
CARDS 2A/C1	Drag Coefficient Subtable
CARDS 2A/D1	Pitching Moment Coefficient Subtable

NOTE: A set of tables for an NACA 0012 airfoil is compiled within the program and stored in the region allocated for Data Table Set No. 10. If IPL(2) = 10, the tenth set of tables input overlays this set of internal 0012 tables. For the reduced core storage version of C81, the 0012 tables are internally stored in the region allocated for Data Table Set No. 2, and if IPL(2) = 2, the second table input overlays the 0012 tables. ++

\+ Additional tables
++ Previously stored as Data Table No. 5

2.5 ROTOR 1 GROUP

(Omit if IPL(3) = 1 or 3)

CARD 30 Rotor 1 Group Identification Card

Col 11 - 70 Identifying Comments

CARD 31

XMR	(1)	Number of blades	
	(2)	Undersling	(in.)
	(3)	Aerodynamic reference center offset, (+ fwd) (ONLY if constant)	(in.)
	(4)	Radius	(ft)
	(5)	Chord (ONLY if constant)	(in.)
	(6)	Total twist (ONLY if linear)	(deg)
	(7)	Flapping stop location	(deg)

CARD 32

XMR	(8)	Stationline } Location of mast pivot	(in.)
	(9)	Buttline } point for mast tilt and	(in.)
	(10)	Waterline } conversion maneuvers	(in.)
	(11)	Blade weight (ignored if IPL(6) $\neq$ 0)	(lb)
	(12)	Blade inertia (ignored if IPL(6) $\neq$ 0)	(slug-ft^2)
	(13)	Rotor-to-engine gear ratio	(Rotor RPM/Engine RPM)
	(14)	Pitch-lag coupling	(deg/deg)

CARD 33

XMR	(15)	Rotor-to-swashplate angle ratio	(deg/deg)
	(16)	Hub-type indicator (0.0 = gimballed)	
	(17)	Flapping stop spring rate	(ft-lb/deg)
	(18)	Flapping spring rate	(ft-lb/deg)
	(19)	Reduced rotor frequency for UNSAN option	(cycles/rev)
	(20)	Lead-lag damper	(ft-lb/deg/sec)
	(21)	Hub extent	(ft)

CARD 34

XMR	(22)	Precone	(deg)
	(23)	Pitch-change axis location (0.0 = 25% chord)	(chords)
	(24)	Pitch-flap coupling angle, δ_3	(deg)
	(25)	Drag coefficient for hub	

	(26)	Lead-lag spring rate	(ft-lb/deg)	
	(27)	Coefficient for tip-vortex effect (0.0 = off)		
	(28)	Currently inactive		

CARD 35

XMR	(29)	Tip sweep angle (+ aft)	(deg)	
	(30)	Tip loss factor (= 0, uses equation)		
	(31)	Moment arm of pitch-link attach point (+ forward)	(in.)	
	(32)	Distance from hub to pitch-horn attach point	(in.)	
	(33)	Coefficient of rotor downwash at fuselage center of pressure		*
	(34)	Currently unused		
	(35)	Pitch-cone coupling ratio (if IPL(6) = 0)	(deg/deg)	

CARD 36

XMR	(36)	Rotor nacelle weight	(lb)	
	(37)	Stationline } Location of rotor nacelle center of gravity	(in.)	
	(38)	Buttline } Location of rotor nacelle center of gravity	(in.)	
	(39)	Waterline } Location of rotor nacelle center of gravity	(in.)	
	(40)	Rotor nacelle differential flat plate drag area	(ft^2)	
	(41)	Distance from mast pivot point to rotor nacelle aerodynamic center	(ft)	
	(42)	1st mass moment of inertia for blade (ignored if IPL(6) $\neq$ 0)	(slug-ft)	

CARD 37

XMR	(43)	Control phasing	(deg)	
	(44)	Longitudinal mast tilt (+ forward)	(deg)	
	(45)	Lateral mast tilt (+ starboard)	(deg)	
	(46)	Mast length	(ft)	
	(47)	Flapping angle at which nonlinear flapping spring is engaged	(deg)	*
	(48)	Nonlinear flapping spring rate	(ft-lb/deg^r)	*
	(49)	r - order of the nonlinearity		*

CARD 38

XMR	(50)	Rotor 1 filter frequency (default is Rotor 1 1/rev) (Hz)		*
	(51)	Currently unused		
	(52)	Currently unused		
	(53)	Currently unused		
	(54)	Currently unused		

(55) Feathering bearing torsional spring rate (in.-lb/deg) *

(56) Neutral angle for feathering bearing spring (deg) *

CARD 39 Blade Radial Station Data (Include only if IPL(4)<0)

XMBS	(1)	Radius to outboard end of Segment No. 1	(in.)
	(2)	Radius to outboard end of Segment No. 2	(in.)
	(3)	Radius to outboard end of Segment No. 3	(in.)
	(4)	Radius to outboard end of Segment No. 4	(in.)
	(5)	Radius to outboard end of Segment No. 5	(in.)
	(6)	Radius to outboard end of Segment No. 6	(in.)
	(7)	Radius to outboard end of Segment No. 7	(in.)

CARD 3A (Include only if IPL(4)<0)

XMBS	(8)	Radius to outboard end of Segment No. 8	(in.)
	(9)	Radius to outboard end of Segment No. 9	(in.)
	(10)	Radius to outboard end of Segment No. 10	(in.)
	(11)	Radius to outboard end of Segment No. 11	(in.)
	(12)	Radius to outboard end of Segment No. 12	(in.)
	(13)	Radius to outboard end of Segment No. 13	(in.)
	(14)	Radius to outboard end of Segment No. 14	(in.)

CARD 3B (Include only if IPL(4)<0)

XMBS	(15)	Radius to outboard end of Segment No. 15	(in.)
	(16)	Radius to outboard end of Segment No. 16	(in.)
	(17)	Radius to outboard end of Segment No. 17	(in.)
	(18)	Radius to outboard end of Segment No. 18	(in.)
	(19)	Radius to outboard end of Segment No. 19	(in.)
	(20)	Radius to outboard end of Segment No. 20	(in.)
	(21)	Currently inactive	

CARDS 3C, 3D, 3E - (include only if XMR(3)≥100.) +

XMACF(1)→XMACF(20) { Airfoil aerodynamic reference center offset distribution, positive forward; Blade Stations 1 to 20 (root to tip) (in.)

CARDS 3F, 3G, 3H - (Include only if XMR(5) = 0.0)

XMC(1)→XMC(20) { Blade chord distribution; Blade Stations No. 1 to 20 (root to tip) (in.)

+ Pylon data moved to separate group

CARDS 3I, 3J, 3K - (Include only if XMR(6)$\geq$100.0)

XMT(1)→XMT(20) { Blade twist distribution; Blade Stations No. 1 to 20 (root to tip) (deg)

CARD 3L Harmonic Blade Shaker (Include only if IPL(14) = 1 or 3) +

XMDI	(1)	Amplitude of shaker force	(lb)
	(2)	Shaker frequency	(/rev)
	(3)	Phase angle of shaker force, Blade 1	(deg)
	(4)	Blade station number at which force is applied	
	(5)	Angle of force relative to beamwise upward (90° is chordwise aft)	(deg)
	(6)	Indicator for type of mode forced	
	(7)	Number of blades shaken (default = all)	

CARD 3M First Harmonic Control Shaker (Include only if IPL(14) = 1 or 3) +

XMDI	(8)	Amplitude of harmonic control motion	(deg)
	(9)	Frequency of harmonic control motion	(/rev)
	(10)	Phase of control motion	(deg)
	(11)	Swashplate rocking axis orientation	(deg)
	(12)	Indicator for type of control motion	
	(13) (14)	} Currently unused	

CARD 3N Second Harmonic Control Shaker (Include only if IPL(14) = 1 or 3) +

XMDI	(15)	Amplitude of harmonic control motion	(deg)
	(16)	Frequency of harmonic control motion	(/rev)
	(17)	Phase of control motion	(deg)
	(18)	Swashplate rocking axis orientation	(deg)
	(19)	Indicator for type of control motion	
	(20) (21)	} Currently unused	

CARD 3O Third Harmonic Control Shaker (Include only if IPL(14) = 1 or 3) +

XMDI	(22)	Amplitude of harmonic control motion	(deg)
	(23)	Frequency of harmonic control motion	(/rev)
	(24)	Phase of control motion	(deg)
	(25)	Swashplate rocking axis orientation	(deg)

+ New cards

(26) Indicator for type of control motion
(27)
(28) Currently unused

CARD 3P - (Include only if IPL(46)<0) (20I2 format)

IDTABM(1)→IDTABM(20) Blade airfoil distribution; Blade Stations No. 1 to 20 (root to tip)

2.6 <u>ROTOR 1 ELASTIC PYLON GROUP</u> (Include only if IPL(9) $\neq$ 0) +

CARD 40 Rotor 1 Elastic Pylon Group Identification Card

CARD 41 First Pylon Mode Shape, Card 1 (include only if IPL(9) $\geq$1)

XMP	(1)	Generalized inertia	(in.-lb-sec^2)
	(2)	Natural frequency	(Hz)
	(3)	Damping ratio	
	(4)	Collective coupling	(rad)
	(5)	Longitudinal cyclic coupling	(rad)
	(6)	Lateral cyclic coupling	(rad)
	(7)	Currently unused	

CARD 42 First Pylon Mode Shape, Card 2 (include with CARD 41)

XMP	(8)	X displacement at top of mast	(in.)
	(9)	Y displacement at top of mast	(in.)
	(10)	Z displacement at top of mast	(in.)
	(11)	θ_x (roll) angle at top of mast	(rad)
	(12)	θ_y (pitch) angle at top of mast	(rad)
	(13)	θ_z (windup) angle at top of mast	(rad)
	(14)	Currently unused	

CARD 43 Second Pylon Mode Shape, Card 1 (include only if IPL(9) $\geq$ 2)

XMP	(15)	Generalized inertia	(in.-lb-sec^2)
	(16)	Natural frequency	(Hz)
	(17)	Damping ratio	
	(18)	Collective coupling	(rad)
	(19)	Longitudinal cyclic coupling	(rad)
	(20)	Lateral cyclic coupling	(rad)
	(21)	Currently unused	

CARD 44 Second Pylon Mode Shape, Card 2 (include with CARD 43)

XMP	(22)	X displacement at top of mast	(in.)
	(23)	Y displacement at top of mast	(in.)
	(24)	Z displacement at top of mast	(in.)
	(25)	θ_x (roll) angle at top of mast	(rad)
	(26)	θ_y (pitch) angle at top of mast	(rad)
	(27)	θ_z (windup) angle at top of mast	(rad)
	(28)	Currently unused	

+ New Group, formerly in main rotor group

CARD 45 Third Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 3$)

XMP	(29)	Generalized inertia	($in.-lb-sec^2$)
	(30)	Natural frequency	(Hz)
	(31)	Damping ratio	
	(32)	Collective coupling	(rad)
	(33)	Longitudinal cyclic coupling	(rad)
	(34)	Lateral cyclic coupling	(rad)
	(35)	Currently unused	

CARD 46 Third Pylon Mode Shape, Card 2 (include with CARD 45)

XMP	(36)	X displacement at top of mast	(in.)
	(37)	Y displacement at top of mast	(in.)
	(38)	Z displacement at top of mast	(in.)
	(39)	θ_x (roll) angle at top of mast	(rad)
	(40)	θ_y (pitch) angle at top of mast	(rad)
	(41)	θ_z (windup) angle at top of mast	(rad)
	(42)	Currently unused	

CARD 47 Fourth Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 4$)

XMP	(43)	Generalized inertia	($in.-lb-sec^2$)
	(44)	Natural frequency	(Hz)
	(45)	Damping ratio	
	(46)	Collective coupling	(rad)
	(47)	Longitudinal cyclic coupling	(rad)
	(48)	Lateral cyclic coupling	(rad)
	(49)	Currently unused	

CARD 48 Fourth Pylon Mode Shape, Card 2 (include with CARD 47)

XMP	(50)	X displacement at top of mast	(in.)
	(51)	Y displacement at top of mast	(in.)
	(52)	Z displacement at top of mast	(in.)
	(53)	θ_x (roll) angle at top of mast	(rad)
	(54)	θ_y (pitch) angle at top of mast	(rad)
	(55)	θ_z (windup) angle at top of mast	(rad)
	(56)	Currently unused	

CARD 49 Fifth Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 5$)

XMP	(57)	Generalized inertia	($in.-lb-sec^2$)
	(58)	Natural frequency	(Hz)

	(59)	Damping ratio	
	(60)	Collective coupling	(rad)
	(61)	Longitudinal cyclic coupling	(rad)
	(62)	Lateral cyclic coupling	(rad)
	(63)	Currently unused	

CARD 4A Fifth Pylon Mode Shape, Card 2 (include with CARD 49)

XMP	(64)	X displacement at top of mast	(in.)
	(65)	Y displacement at top of mast	(in.)
	(66)	Z displacement at top of mast	(in.)
	(67)	θ_x (roll) angle at top of mast	(rad)
	(68)	θ_y (pitch) angle at top of mast	(rad)
	(69)	θ_z (windup) angle at top of mast	(rad)
	(70)	Currently unused	

CARD 4B Sixth Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 6$)

XMP	(71)	Generalized inertia	(in.-lb-sec^2)
	(72)	Natural frequency	(Hz)
	(73)	Damping ratio	
	(74)	Collective coupling	(rad)
	(75)	Longitudinal cyclic coupling	(rad)
	(76)	Lateral cyclic coupling	(rad)
	(77)	Currently unused	

CARD 4C Sixth Pylon Mode Shape, Card 2 (include with CARD 4B)

XMP	(78)	X displacement at top of mast	(in.)
	(79)	Y displacement at top of mast	(in.)
	(80)	Z displacement at top of mast	(in.)
	(81)	θ_x (roll) angle at top of mast	(rad)
	(82)	θ_y (pitch) angle at top of mast	(rad)
	(83)	θ_z (windup) angle at top of mast	(rad)
	(84)	Currently unused	

CARD 4D Seventh Pylon Mode Shape, Card 1 (include only if $|IPL(9)| \geq 7$)

XMP	(85)	Generalized inertia	(in.-lb-sec^2)
	(86)	Natural frequency	(Hz)
	(87)	Damping ratio	
	(88)	Collective coupling	(rad)
	(89)	Longitudinal cyclic coupling	(rad)
	(90)	Lateral cyclic coupling	
	(91)	Currently unused	

CARD 4E Seventh Pylon Mode Shape, Card 2 (include with CARD 4D)

XMP (92) X displacement at top of mast
(93) Y displacement at top of mast
(94) Z displacement at top of mast
(95) θ_x (roll) angle at top of mast
(96) θ_y (pitch) angle at top of mast
(97) θ_z (windup) angle at top of mast
(98) Currently unused

CARD 4F Eighth Pylon Mode Shape, Card 1 (include only if IPL(9) $\geq$ 8)

XMP (99) Generalized inertia (in.-lb-sec²)
(100) Natural frequency (Hz)
(101) Damping ratio
(102) Collective coupling (rad)
(103) Longitudinal cyclic coupling
(104) Lateral cyclic coupling
(105) Currently unused

CARD 4G Eighth Pylon Mode Shape, Card 2 (include with CARD 4F)

XMP (106) X displacement at top of mast
(107) Y displacement at top of mast
(108) Z displacement at top of mast
(109) θ_x (roll) angle at top of mast
(110) θ_y (pitch) angle at top of mast
(111) θ_z (windup)angle at top of mast
(112) Currently unused

CARD 4H Ninth Pylon Mode Shape, Card 1 (include only if IPL(9) $\geq$ 9)

XMP (113) Generalized inertia (in.-lb-sec²)
(114) Natural frequency (Hz)
(115) Damping ratio
(116) Collective coupling (rad)
(117) Longitudinal cyclic coupling (rad)
(118) Lateral cyclic coupling (rad)
(119) Currently unused

CARD 4I Ninth Pylon Mode Shape, Card 2 (include with CARD 4H)

XMP (120) X displacement at top of mast
(121) Y displacement at top of mast (in.)

	(122)	Z displacement at top of mast	(in.)
	(123)	r_x (roll) angle at top of mast	(rad)
	(124)	r_y (pitch) angle at top of mast	(rad)
	(125)	r_z (windup) angle at top of mast	(rad)
	(126)	Currently unused	

CARD 4J Tenth Pylon Mode Shape, Card 1 (include only if IPL(9) = 10)

XMP	(127)	Generalized inertia	(in.-lb-sec^2)
	(128)	Natural frequency	(Hz)
	(129)	Damping ratio	
	(130)	Collective coupling	(rad)
	(131)	Longitudinal cyclic coupling	(rad)
	(132)	Lateral cyclic coupling	(rad)
	(133)	Currently unused	

CARD 4K Tenth Pylon Mode Shape, Card 2 (include with CARD 4J)

XMP	(134)	X displacement at top of mast	(in.)
	(135)	Y displacement at top of mast	(in.)
	(136)	Z displacement at top of mast	(in.)
	(137)	θ_x (roll) angle at top of mast	(rad)
	(138)	θ_y (pitch) angle at top of mast	(rad)
	(139)	θ_z (windup) angle at top of mast	(rad)
	(140)	Currently unused	

CARD 4L through 4L + IPL(9) must be input if IPL(9) $\neq$ 0. These cards contain the data for calculation of linear accelerations at a specified point in the fixed system. All IPL(9) +1 cards must be input.

CARD 4L

XFSMS	(1,1)	Stationline	Location of specified point at which accelerations are desired	(in.)
	(2,1)	Buttline		(in.)
	(3,1)	Waterline		(in.)
	(4,1)	Currently unused		
	(5,1)			
	(6,1)			
	(7,1)			

CARD 4M (Include only if $|IPL(9)| \geq 1$)

XFSMS	(8,1) X_1	Mode shape components of pylon mode 1 at the specified point	(in.)
	(9,1) Y_1		(in.)
	(10,1) Z_1		(in.)
	(11,1) θ_{x_1}		(rad)
	(12,1) θ_{y_1}		(rad)
	(13,1) θ_{z_1}		(rad)
	(14,1) Currently unused		

CARD 4N (Include only if $|IPL(9)| \geq 2$)

XFSMS	(15,1) X_2	Mode shape components of pylon mode 2 at the specified point	(in.)
	(16,1) Y_2		(in.)
	(17,1) Z_2		(in.)
	(18,1) θ_{x_2}		(rad)
	(19,1) θ_{y_2}		(rad)
	(20,1) θ_{z_2}		(rad)
	(21,1) Currently unused		

CARD 4O (Include only if $|IPL(9)| \geq 3$)

XFSMS	(22,1) X_3	Mode shape components of pylon mode 3 at the specified point	(in.)
	(23,1) Y_3		(in.)
	(24,1) Z_3		(in.)
	(25,1) θ_{x_3}		(rad)
	(26,1) θ_{y_3}		(rad)
	(27,1) θ_{z_3}		(rad)
	(28,1) Currently unused		

CARD 4P (Include only if $|IPL(9)| \geq 4$)

XFSMS (29,1)	X_4	Mode shape components of pylon mode 4 at the specified point	(in.)
(30,1)	Y_4		(in.)
(31,1)	Z_4		(in.)
(32,1)	θ_{x_4}		(rad)
(33,1)	θ_{y_4}		(rad)
(34,1)	θ_{z_4}		(rad)
(35,1)	Currently unused		

CARD 4Q (Include only if $|IPL(9)| \geq 5$)

XFSMS (36,1)	X_5	Mode shape components of pylon mode 5 at the specified point	(in.)
(37,1)	Y_5		(in.)
(38,1)	Z_5		(in.)
(39,1)	θ_{x_5}		(rad)
(40,1)	θ_{y_5}		(rad)
(41,1)	θ_{z_5}		(rad)
(42,1)	Currently unused		

CARD 4R (Include only if $|IPL(9)| \geq 6$)

XFSMS (43,1)	X_6	Mode shape components of pylon mode 6 at the specified point	(in.)
(44,1)	Y_6		(in.)
(45,1)	Z_6		(in.)
(46,1)	θ_{x_6}		(rad)
(47,1)	θ_{y_6}		(rad)
(48,1)	θ_{z_6}		(rad)
(49,1)	Currently unused		

CARD 4S (Include only if $|IPL(9)| \geq 7$)

XFSMS	(50,1)	X_7	Mode shape components of pylon mode 7 at the	(in.)
	(51,1)	Y_7		(in.)
	(52,1)	Z_7		(in.)
	(53,1)	θ_{x_7}		(rad)
	(54,1)	θ_{y_7}		
	(55,1)	θ_{z_7}		(rad)
	(56,1)	Currently unused		

CARD 4T (Include only if $|IPL(9)| \geq 8$)

XFSMS	(57,1)	X_8	Mode shape components of pylon mode 8 at the specified point	(in.)
	(58,1)	Y_8		(in.)
	(59,1)	Z_8		(in.)
	(60,1)	θ_{x_8}		(rad)
	(61,1)	θ_{y_8}		(rad)
	(62,1)	θ_{z_8}		(rad)
	(63,1)	Currently unused		

CARD 4U (Include only if $|IPL(9)| \geq 9$)

XFSMS	(64,1)	X_9	Mode shape components of pylon mode 9 at the specified point	(in.)
	(65,1)	Y_9		(in.)
	(66,1)	Z_9		(in.)
	(67,1)	θ_{x_9}		(rad)
	(68,1)	θ_{y_9}		(rad)
	(69,1)	θ_{z_9}		(rad)
	(70,1)	Currently unused		

CARD 4V (Include only if $|IPL(9)| = 10$)

XFSMS	(71,1)	X_{10}	Mode shape components of pylon mode 10 at the specified point	(in.)
	(72,1)	Y_{10}		(in.)
	(73,1)	Z_{10}		(in.)
	(74,1)	$\theta_{x_{10}}$		(rad)
	(75,1)	$\theta_{y_{10}}$		(rad)
	(76,1)	$\theta_{z_{10}}$		(rad)
	(77,1)	Currently unused		

2.7 ROTOR 1 ELASTIC BLADE DATA GROUP

(Omit if IPL(6) = 0)

CARD 50 Rotor 1 Elastic Blade Data Group Identification Card

Col 11 - 70 Identifying Comments

2.7.1 Average Running Weight of Blade Segment

CARD 51/A1

XMW	(1)	Blade Segment No. 1 (root)	(lb/in.)
	(2)	Blade Segment No. 2	(lb/in.)
	(3)	Blade Segment No. 3	(lb/in.)
	(4)	Blade Segment No. 4	(lb/in.)
	(5)	Blade Segment No. 5	(lb/in.)
	(6)	Blade Segment No. 6	(lb/in.)
	(7)	Blade Segment No. 7	(lb/in.)

CARD 51/A2

XMW	(8)	Blade Segment No. 8	(lb/in.)
	(9)	Blade Segment No. 9	(lb/in.)
	(10)	Blade Segment No. 10	(lb/in.)
	(11)	Blade Segment No. 11	(lb/in.)
	(12)	Blade Segment No. 12	(lb/in.)
	(13)	Blade Segment No. 13	(lb/in.)
	(14)	Blade Segment No. 14	(lb/in.)

CARD 51/A3

XMW	(15)	Blade Segment No. 15	(lb/in.)
	(16)	Blade Segment No. 16	(lb/in.)
	(17)	Blade Segment No. 17	(lb/in.)
	(18)	Blade Segment No. 18	(lb/in.)
	(19)	Blade Segment No. 19	(lb/in.)
	(20)	Blade Segment No. 20	(lb/in.)
	(21)	Tip Weight	(lb)

2.7.2 Average Running Beamwise Mass Moment of Inertia of Blade Segment

CARD 51/B1

XMW	(22)	Blade Segment No. 1 (root)	(in.-lb-sec^2/in.)
	(23)	Blade Segment No. 2	(in.-lb-sec^2/in.)
	(24)	Blade Segment No. 3	(in.-lb-sec^2/in.)
	(25)	Blade Segment No. 4	(in.-lb-sec^2/in.)
	(26)	Blade Segment No. 5	(in.-lb-sec^2/in.)

	(27)	Blade Segment No. 6	(in.-lb-sec^2/in.)
	(28)	Blade Segment No. 7	(in.-lb-sec^2/in.)

CARD 51/B2

XMW	(29)	Blade Segment No. 8	(in.-lb-sec^2/in.)
	(30)	Blade Segment No. 9	(in.-lb-sec^2/in.)
	(31)	Blade Segment No. 10	(in.-lb-sec^2/in.)
	(32)	Blade Segment No. 11	(in.-lb-sec^2/in.)
	(33)	Blade Segment No. 12	(in.-lb-sec^2/in.)
	(34)	Blade Segment No. 13	(in.-lb-sec^2/in.)
	(35)	Blade Segment No. 14	(in.-lb-sec^2/in.)

CARD 51/B3

XMW	(36)	Blade Segment No. 15	(in.-lb-sec^2/in.)
	(37)	Blade Segment No. 16	(in.-lb-sec^2/in.)
	(38)	Blade Segment No. 17	(in.-lb-sec^2/in.)
	(39)	Blade Segment No. 18	(in.-lb-sec^2/in.)
	(40)	Blade Segment No. 19	(in.-lb-sec^2/in.)
	(41)	Blade Segment No. 20	(in.-lb-sec^2/in.)
	(42)	Currently unused	

2.7.3 Average Running Chordwise Mass Moment of Inertia of Blade Segment

CARD 51/C1

XMW	(43)	Blade Segment No. 1 (root)	(in.-lb-sec^2/in.)
	(44)	Blade Segment No. 2	(in.-lb-sec^2/in.)
	(45)	Blade Segment No. 3	(in.-lb-sec^2/in.)
	(46)	Blade Segment No. 4	(in.-lb-sec^2/in.)
	(47)	Blade Segment No. 5	(in.-lb-sec^2/in.)
	(48)	Blade Segment No. 6	(in.-lb-sec^2/in.)
	(49)	Blade Segment No. 7	(in.-lb-sec^2/in.)

CARD 51/C2

XMW	(50)	Blade Segment No. 8	(in.-lb-sec^2/in.)
	(51)	Blade Segment No. 9	(in.-lb-sec^2/in.)
	(52)	Blade Segment No. 10	(in.-lb-sec^2/in.)
	(53)	Blade Segment No. 11	(in.-lb-sec^2/in.)
	(54)	Blade Segment No. 12	(in.-lb-sec^2/in.)
	(55)	Blade Segment No. 13	(in.-lb-sec^2/in.)
	(56)	Blade Segment No. 14	(in.-lb-sec^2/in.)

CARD 51/C3

XMW	(57)	Blade Segment No. 15	(in.-lb-sec^2/in.)
	(58)	Blade Segment No. 16	(in.-lb-sec^2/in.)

(59) Blade Segment No. 17 (in.-lb-sec^2/in.)
(60) Blade Segment No. 18 (in.-lb-sec^2/in.)
(61) Blade Segment No. 19 (in.-lb-sec^2/in.)
(62) Blade Segment No. 20 (in.-lb-sec^2/in.)
(63) Currently unused

2.7.4 Average Beamwise Center of Gravity Offset of Blade Segment

CARD 51/D1

XMW	(64)	Blade Segment No. 1 (root)	(in.)
	(65)	Blade Segment No. 2	(in.)
	(66)	Blade Segment No. 3	(in.)
	(67)	Blade Segment No. 4	(in.)
	(68)	Blade Segment No. 5	(in.)
	(69)	Blade Segment No. 6	(in.)
	(70)	Blade Segment No. 7	(in.)

CARD 51/D2

XMW	(71)	Blade Segment No. 8	(in.)
	(72)	Blade Segment No. 9	(in.)
	(73)	Blade Segment No. 10	(in.)
	(74)	Blade Segment No. 11	(in.)
	(75)	Blade Segment No. 12	(in.)
	(76)	Blade Segment No. 13	(in.)
	(77)	Blade Segment No. 14	(in.)

CARD 51/D3

XMW	(78)	Blade Segment No. 15	(in.)
	(79)	Blade Segment No. 16	(in.)
	(80)	Blade Segment No. 17	(in.)
	(81)	Blade Segment No. 18	(in.)
	(82)	Blade Segment No. 19	(in.)
	(83)	Blade Segment No. 20	(in.)
	(84)	cg offset of tipweight	(in.)

2.7.5 Average Chordwise Center of Gravity Offset of Blade Segment

CARD 51/E1

XMW	(85)	Blade Segment No. 1 (root)	(in.)
	(86)	Blade Segment No. 2	(in.)
	(87)	Blade Segment No. 3	(in.)
	(88)	Blade Segment No. 4	(in.)
	(89)	Blade Segment No. 5	(in.)
	(90)	Blade Segment No. 6	(in.)
	(91)	Blade Segment No. 7	(in.)

CARD 51/E2

XMW	(92)	Blade Segment No. 8	(in.)
	(93)	Blade Segment No. 9	(in.)
	(94)	Blade Segment No. 10	(in.)
	(95)	Blade Segment No. 11	(in.)
	(96)	Blade Segment No. 12	(in.)
	(97)	Blade Segment No. 13	(in.)
	(98)	Blade Segment No. 14	(in.)

CARD 51/E3

XMW	(99)	Blade Segment No. 15	(in.)
	(100)	Blade Segment No. 16	(in.)
	(101)	Blade Segment No. 17	(in.)
	(102)	Blade Segment No. 18	(in.)
	(103)	Blade Segment No. 19	(in.)
	(104)	Blade Segment No. 20	(in.)
	(105)	cg offset of tipweight	(in.)

2.7.6 Blade Mode Shape Data

The IPL(6) elastic mode shapes for Rotor 1 are input here. Each mode shape is input on (|IPL(4)| +5) cards. The format for all the cards in a mode shape is 6F10.0. In the following discussion, MN is the mode shape number ($\leq$IPL(6)).

2.7.6.1 First Mode (MN = 1)

CARD 52/A1 Blade General Mode Shape Data

XGMS	(1,MN)	Mode type indicator		
	(2,MN)	Natural frequency	(/rev)	
	(3,MN)	Generalized inertia	(slug-ft^2)	
	(4,MN)	Modal damping ratio		
	(5,MN)	Inplane hub shear coefficient	(lb)	
	(6,MN)	Out-of-plane hub shear coefficient	(lb)	

CARD 52/A2

XGMS	(7,MN)	Pitch-link load coefficient	(lb)	
	(8,MN)	Lag angle	(deg)	
	(9,MN)	Reference RPM	(rpm)	
	(10,MN)	Reference collective	(deg)	
	(11,MN)	Pitch bearing out-of-plane slope	(deg)	*
	(12,MN)	Pitch bearing inplane slope	(deg)	*

CARD 52/A3

XGMS	(13,MN)	Integral of (OP component) x (r)dm	(slug-ft^2)

(14,MN)	Integral of (OP component)dm	(slug-ft)	
(15,MN)	Integral of (IP component) x (r)dm	(slug-ft^2)	
(16,MN)	Integral of (IP component)dm	(slug-ft)	
(17,MN)	Pitch bearing out-of-plane displacement	(ft)	*
(18,MN)	Pitch bearing inplane displacement	(ft)	*

CARD 52/B1 Blade Mode Shape

Mode Shape Data at Station No. 0 (Center of Rotation)

(1)	Out-of-plane displacement	(ft)
(2)	Inplane displacement	(ft)
(3)	Torsional displacement	(deg)
(4)	Out-of-plane bending moment coefficient	(ft-lb)
(5)	Inplane bending moment coefficient	(ft-lb)
(6)	Torsional moment coefficient	(ft-lb)

CARD 52/B2 Blade Mode Shape Data at Station No. 1 (XMBS(1))

(7)	Out-of-plane displacement	(ft)
(8)	Inplane displacement	(ft)
(9)	Torsional displacement	(deg)
(10)	Out-of-plane bending moment coefficient	(ft-lb)
(11)	Inplane bending moment coefficient	(ft-lb)
(12)	Torsional moment coefficient	(ft-lb)

CARD 52/B3
CARD 52/B4
etc.
.
.
.

Format repeated until there are (|IPL(4)| +1) cards, one for each station

CARD 52/C1 Cyclic Detuning Data

(1)	Natural frequency at low rpm and low pitch angle	(cpm)
(2)	Natural frequency at low rpm and high pitch angle	(cpm)
(3)	Natural frequency at high rpm and low pitch angle	(cpm)
(4)	Natural frequency at high rpm and high pitch angle	(cpm)
(5)	Difference between reference pitch angle and high or low value	(deg)
(6)	Difference between reference rpm and either high or low value	(rpm)

2.7.6.2 <u>Second and Subsequent Blade Modes</u>

CARDS 53/A1 through 53/C1 (Include only if IPL(6)$\geq$2) (MN = 2)

Input sequence and format similar to that of blade mode 1.

CARDS 54/A1 through 54/C1 (Include only if IPL(6)$\geq$3) (MN = 3)

Input sequence and format similar to that of blade mode 1.

.
.
.

CARDS 5C/A1 through 5C/C1 (Include only if IPL(6)=11) (MN = 11)

Input sequence and format similar to that of blade mode 1.

2.8 ROTOR 2 GROUP

(Omit if IPL(3) = 2 or 3)

CARD 60 Rotor 2 Group Identification Card

Col 11 - 70 Identifying Comments

CARD 61

XTR	(1)	Number of blades	
	(2)	Undersling	(in.)
	(3)	Aerodynamic reference center offset, + fwd (ONLY if constant)	(in.)
	(4)	Radius	(ft)
	(5)	Chord (ONLY if constant)	(in.)
	(6)	Total twist (ONLY if linear)	(deg)
	(7)	Flapping stop location	(deg)

CARD 62

XTR	(8)	Stationline — Location of mast pivot	(in.)
	(9)	Buttline — point for mast tilt and	(in.)
	(10)	Waterline — conversion maneuvers	(in.)
	(11)	Blade weight (ignored if IPL(7) $\neq$ 0)	(lb)
	(12)	Blade inertia (ignored if IPL(7) $\neq$ 0)	(slug-ft^2)
	(13)	Rotor-to-engine gear ratio(Rotor RPM/Engine RPM)	
	(14)	Pitch-lag coupling	(deg/deg)

CARD 63

XTR	(15)	Rotor-to-swashplate angle ratio	(deg/deg)
	(16)	Hub-type indicator (0.0 = gimballed)	
	(17)	Flapping stop spring rate	(ft-lb/deg)
	(18)	Flapping spring rate	(ft-lb/deg)
	(19)	Reduced rotor frequency for UNSAN option	(cycles/rev)
	(20)	Lead-lag damper	(ft-lb/deg/sec)
	(21)	Hub extent	(ft)

CARD 64

XTR	(22)	Precone	(deg)
	(23)	Pitch change axis location (0.0 = 25% chord)	(chords)
	(24)	Pitch-flap coupling angle, δ_3	(deg)
	(25)	Drag coefficient for hub	
	(26)	Lead-lag spring rate	(ft-lb/deg)
	(27)	Coefficient for tip vortex effect (0.0 = off)	
	(28)	Sidewash coefficient	

CARD 65

XTR	(29)	Tip sweep angle (+ aft)	(deg)	
	(30)	Tip loss factor (= 0, uses equations)		
	(31)	Moment arm of pitch-link attach point (+ fwd)	(in.)	
	(32)	Distance from hub to pitch-horn attach point		
	(33)	Coefficient of rotor downwash at fuselage center of pressure		*
	(34)	Currently unused		
	(35)	Pitch-cone coupling ratio (if IPL(7) = 0)	(deg/deg)	

CARD 66

XTR	(36)	Rotor nacelle weight	(lb)	
	(37)	Stationline } Location of rotor nacelle	(in.)	
	(38)	Buttline } center of gravity	(in.)	
	(39)	Waterline	(in.)	
	(40)	Rotor nacelle differential flat plate drag area	(ft^2)	
	(41)	Distance from mast pivot point to rotor nacelle aerodynamic center	(ft)	
	(42)	1st mass moment of inertia for blade (ignored if IPL(7) $\neq$ 0)	(slug-ft)	

CARD 67

XTR	(43)	Control phasing	(deg)	
	(44)	Longitudinal mast tilt (+ fwd)	(deg)	
	(45)	Lateral mast tilt (= ±90 for tail rotor)	(deg)	
	(46)	Mast length	(ft)	
	(47)	Flapping angle at which nonlinear flapping spring is engaged	(deg)	*
	(48)	Nonlinear flapping spring rate	(ft-lbf/deg^r)	*
	(49)	r - order of the nonlinearity		*

CARD 68

XTR	(50)	Rotor 2 filter frequency (default is Rotor 2 1/rev)	(Hz)	*
	(51) (52) (53) (54)	Currently unused		
	(55)	Feathering bearing torsional spring rate	(in.-lb/deg)	*
	(56)	Neutral angle for feathering bearing spring	(deg)	*

CARD 69 Blade Radial Station Data (Include only if IPL(5)<0)

XTBS	(1)	Radius to outboard end of Segment No. 1	(in.)
	(2)	Radius to outboard end of Segment No. 2	(in.)
	(3)	Radius to outboard end of Segment No. 3	(in.)
	(4)	Radius to outboard end of Segment No. 4	(in.)
	(5)	Radius to outboard end of Segment No. 5	(in.)
	(6)	Radius to outboard end of Segment No. 6	(in.)
	(7)	Radius to outboard end of Segment No. 7	(in.)

CARD 6A (Include only if IPL(5)<0)

XTBS	(8)	Radius to outboard end of Segment No. 8	(in.)
	(9)	Radius to outboard end of Segment No. 9	(in.)
	(10)	Radius to outboard end of Segment No. 10	(in.)
	(11)	Radius to outboard end of Segment No. 11	(in.)
	(12)	Radius to outboard end of Segment No. 12	(in.)
	(13)	Radius to outboard end of Segment No. 13	(in.)
	(14)	Radius to outboard end of Segment No. 14	(in.)

CARD 6B (Include only if IPL(5)<0)

XTBS	(15)	Radius to outobard end of Segment No. 15	(in.)
	(16)	Radius to outboard end of Segment No. 16	(in.)
	(17)	Radius to outboard end of Segment No. 17	(in.)
	(18)	Radius to outboard end of Segment No. 18	(in.)
	(19)	Radius to outboard end of Segment No. 19	(in.)
	(20)	Radius to outboard end of Segment No. 20	(in.)
	(21)	Radius to outboard end of Segment No. 21	(in.)

CARDS 6C, 6D, 6E - (Include only if XTR(3)≥100.) +

XTACF(1)→XTACF(20) Airfoil aerodynamic reference center offset distribution, + fwd (root to tip) (in.)

CARDS 6F, 6G, 6H - (Include only if XTR(5) = 0.0)

XTC(1)→XTC(20) Blade chord distribution (root to tip)(in.)

CARDS 6I, 6J, 6K - (Include only if XTR(6)≥100.0)

XTT(1)→XTT(20) Blade twist distribution (root to tip)(deg)

CARD 6L Harmonic Blade Shaker (Include only if IPL(14) = 2 or 3) ++

XTDI	(1)	Amplitude of shaker force	(lb)
	(2)	Shaker frequency	(/rev)

\+ Pylon data moved to separate group
++ New card

(3) Phase angle of shaker force, blade 1 (deg)
(4) Blade station number at which force is applied
(5) Angle of force relative to beamwise upward (90° is chordwise aft) (deg)
(6) Indicator for type of mode forced
(7) Number of blades shaken (default = all)

CARD 6M First Harmonic Control Shaker (Include only if IPL(14) = 2 or 3) +

XTDI (8) Amplitude of harmonic control motion (deg)
(9) Frequency of harmonic control motion (/rev)
(10) Phase of control motion (deg)
(11) Swashplate rocking axis orientation (deg)
(12) Indicator for type of control motion
(13) Number of blades with harmonic control motion
(14) Currently unused

CARD 6N Second Harmonic Control Shaker (Include only if IPL(14) = 2 or 3) +

(15) Amplitude of harmonic control motion (deg)
(16) Frequency of harmonic control motion (/rev)
(17) Phase of control motion (deg)
(18) Swashplate rocking axis orientation (deg) 6
(19) Indicator for type of control motion B
(20) Number of blades with harmonic control motion
(21) Currently unused

CARD 6O Third Harmonic Control Shaker (Include only if IPL(14) = 2 or 3) +

XTDI (22) Amplitude of harmonic control motion (deg)
(23) Frequency of harmonic control motion (/rev)
(24) Phase of control motion (deg)
(25) Swashplate rocking axis orientation (deg)
(26) Indicator for type of control motion
(27) Number of blades with harmonic control motion
(28) Currently unused

CARD 6P - (Include only if IPL(47)<0) (20I2 format) *

IDTABT(1)→IDTABT(20) { Blade airfoil distribution; blade Stations 1 to 20 (root to tip)

+ New card

2.9 ROTOR 2 ELASTIC PYLON GROUP (Include only if IPL(10) ≠ 0) +

CARD 70 Rotor 2 Elastic Pylon Group Identification Card

CARD 71 First Pylon Mode Shape, Card 1 (include only if IPL(10) ≥1)

XTP	(1)	Generalized inertia	(in.-lb-sec^2)
	(2)	Natural frequency	(Hz)
	(3)	Damping ratio	
	(4)	Collective coupling	(rad)
	(5)	Longitudinal cyclic coupling	(rad)
	(6)	Collective coupling	(rad)
	(7)	Currently unused	

CARD 72 First Pylon Mode Shape, Card 2 (include with CARD 71)

XTP	(8)	X displacement at top of mast	(in.)
	(9)	Y displacement at top of mast	(in.)
	(10)	Z displacement at top of mast	(in.)
	(11)	θ_x (roll) angle at top of mast	(rad)
	(12)	θ_y (pitch) angle at top of mast	(rad)
	(13)	θ_z (windup) angle at top of mast	(rad)
	(14)	Currently unused	

CARD 73 Second Pylon Mode Shape, Card 1 (include only if IPL(10) ≥2)

XTP	(15)	Generalized inertia	(in.-lb-sec^2)
	(16)	Natural frequency	(Hz)
	(17)	Damping ratio	
	(18)	Collective coupling	(rad)
	(19)	Longitudinal cyclic coupling	(rad)
	(20)	Lateral cyclic coupling	(rad)
	(21)	Currently unused	

CARD 74 Second Pylon Mode Shape, Card 2 (include with CARD 73)

XTP	(22)	X displacement at top of mast	(in.)
	(23)	Y displacement at top of mast	(in.)
	(24)	Z displacement at top of mast	(in.)
	(25)	θ_x (roll) angle at top of mast	(rad)
	(26)	θ_y (pitch) angle at top of mast	(rad)

+ New Group, formerly in main rotor group

	(27)	θ_z (windup) angle at top of mast	(rad)
	(28)	Currently unused	

CARD 75 Third Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 3$)

XTP	(29)	Generalized inertia	(in.-lb-sec^2)
	(30)	Natural frequency	(Hz)
	(31)	Damping ratio	
	(32)	Collective coupling	(rad)
	(33)	Longitudinal cyclic coupling	(rad)
	(34)	Lateral cyclic coupling	(rad)
	(35)	Currently unused	

CARD 76 Third Pylon Mode Shape, Card 2 (include with CARD 75)

XTP	(36)	X displacement at top of mast	(in.)
	(37)	Y displacement at top of mast	(in.)
	(38)	Z displacement at top of mast	(in.)
	(39)	θ_x (roll) angle at top of mast	(rad)
	(40)	θ_y (pitch) angle at top of mast	(rad)
	(41)	θ_z (windup) angle at top of mast	(rad)
	(42)	Currently unused	

CARD 77 Fourth Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 4$)

XTP	(43)	Generalized inertia	(in.-lb-sec^2)
	(44)	Natural frequency	(Hz)
	(45)	Damping ratio	
	(46)	Collective coupling	(rad)
	(47)	Longitudinal cyclic coupling	(rad)
	(48)	Lateral cyclic coupling	(rad)
	(49)	Currently unused	

CARD 78 Fourth Pylon Mode Shape, Card 2 (include with CARD 77)

XTP	(50)	X displacement at top of mast	(in.)
	(51)	Y displacement at top of mast	(in.)
	(52)	Z displacement at top of mast	(in.)
	(53)	θ_x (roll) angle at top of mast	(rad)
	(54)	θ_y (pitch) angle at top of mast	(rad)
	(55)	θ_z (windup) angle at top of mast	(rad)
	(56)	Currently unused	

CARD 79 Fifth Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 5$)

XTP	(57)	Generalized inertia	(in.-lb-sec^2)
	(58)	Natural frequency	(Hz)
	(59)	Damping ratio	
	(60)	Collective coupling	(rad)
	(61)	Longitudinal cyclic coupling	(rad)
	(62)	Lateral cyclic coupling	(rad)
	(63)	Currently unused	

CARD 7A Fifth Pylon Mode Shape, Card 2 (include with CARD 79)

XTP	(64)	X displacement at top of mast	(in.)
	(65)	Y displacement at top of mast	(in.)
	(66)	Z displacement at top of mast	(in.)
	(67)	θ_x (roll) angle at top of mast	(rad)
	(68)	θ_y (pitch) angle at top of mast	(rad)
	(69)	θ_z (windup) angle at top of mast	(rad)
	(70)	Currently unused	

CARD 7B Sixth Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 6$)

XTP	(71)	Generalized inertia	(in.-lb-sec^2)
	(72)	Natural frequency	(Hz)
	(73)	Damping ratio	
	(74)	Collective coupling	(rad)
	(75)	Longitudinal cyclic coupling	(rad)
	(76)	Lateral cyclic coupling	(rad)
	(77)	Currently unused	

CARD 7C Sixth Pylon Mode Shape, Card 2 (include with CARD 7B)

XTP	(78)	X displacement at top of mast	(in.)
	(79)	Y displacement at top of mast	(in.)
	(80)	Z displacement at top of mast	(in.)
	(81)	θ_x (roll) angle at top of mast	(rad)
	(82)	θ_y (pitch) angle at top of mast	(rad)
	(83)	θ_z (windup) angle at top of mast	(rad)
	(84)	Currently unused	

CARD 7D Seventh Pylon Mode Shape, Card 1 (include only if |IPL(10)| $\geq$ 7)

XTP	(85)	Generalized inertia	(in.-lb-sec^2)
	(86)	Natural frequency	(Hz)
	(87)	Damping ratio	
	(88)	Collective coupling	(rad)
	(89)	Longitudinal cyclic coupling	(rad)
	(90)	Lateral cyclic coupling	(rad)
	(91)	Currently unused	

CARD 7E Seventh Pylon Mode Shape, Card 2 (include with CARD 7D)

XTP	(92)	X displacement at top of mast	(in.)
	(93)	Y displacement at top of mast	(in.)
	(94)	Z displacement at top of mast	(in.)
	(95)	θ_x (roll) angle at top of mast	(rad)
	(96)	θ_y (pitch) angle at top of mast	(rad)
	(97)	θ_z (windup) angle at top of mast	(rad)
	(98)	Currently unused	

CARD 7F Eighth Pylon Mode Shape, Card 1 (include only if |IPL(10)| $\geq$ 8)

XTP	(99)	Generalized inertia	(in.-lb-sec^2)
	(100)	Natural frequency	(Hz)
	(101)	Damping ratio	
	(102)	Collective coupling	(rad)
	(103)	Longitudinal cyclic coupling	(rad)
	(104)	Lateral cyclic coupling	(rad)
	(105)	Currently unused	

CARD 7G Eighth Pylon Mode Shape, Card 2 (include with CARD 7F)

XTP	(106)	X displacement at top of mast	(in.)
	(107)	Y displacement at top of mast	(in.)
	(108)	Z displacement at top of mast	(in.)
	(109)	θ_x (roll) angle at top of mast	(rad)
	(110)	θ_y (pitch) angle at top of mast	(rad)
	(111)	θ_z (windup) angle at top of mast	(rad)
	(112	Currently unused	

CARD 7H Ninth Pylon Mode Shape, Card 1 (include only if $|IPL(10)| \geq 9$)

XTP	(113)	Generalized inertia	(in.-lb-sec^2)
	(114)	Natural frequency	(Hz)
	(115)	Damping ratio	
	(116)	Collective coupling	(rad)
	(117)	Longitudinal cyclic coupling	(rad)
	(118)	Lateral cyclic coupling	(rad)
	(119)	Currently unused	

CARD 7I Ninth Pylon Mode Shape, Card 2 (include with CARD 7I)

XTP	(120)	X displacement at top of mast	(in.)
	(121)	Y displacement at top of mast	(in.)
	(122)	Z displacement at top of mast	(in.)
	(123)	θ_x (roll) angle at top of mast	(rad)
	(124)	θ_y (pitch) angle at top of mast	(rad)
	(125)	θ_z (windup) angle at top of mast	(rad)
	(126)	Currently unused	

CARD 7J Tenth Pylon Mode Shape, Card 1 (include only if $|IPL(10)| = 10$)

XTP	(127)	Generalized inertia	(in.-lb-sec^2)
	(128)	Natural frequency	(Hz)
	(129)	Damping ratio	
	(130)	Collective coupling	(rad)
	(131)	Longitudinal cyclic coupling	(rad)
	(132)	Lateral cyclic coupling	(rad)
	(133)	Currently unused	

CARD 7K Tenth Pylon Mode Shape, Card 2 (include with CARD 7J)

XTP	(134)	X displacement at top of mast	(in.)
	(135)	Y displacement at top of mast	(in.)
	(136)	Z displacement at top of mast	(in.)
	(137)	θ_x (roll) angle at top of mast	(rad)
	(138)	θ_y (pitch) angle at top of mast	(rad)
	(139)	θ_z (windup) angle at top of mast	(rad)
	(140)	Currently unused	

The program does not contain analysis to compute the vibration at a given point on the airframe due to Rotor 2 pylon vibration. Therefore, no additional cards are input in the Rotor 2 Elastic Pylon Group.

2.10 ROTOR 2 ELASTIC BLADE DATA GROUP

(Omit if IPL(7) = 0)

CARD 80 Rotor 2 Elastic Blade Data Group Identification Card

Col 11 - 70 Identifying Comments

2.10.1 Average Running Weight of Blade Segment

CARD 81/A1

XTW (1)	Blade Segment No. 1 (root)	(lb/in.)
(2)	Blade Segment No. 2	(lb/in.)
(3)	Blade Segment No. 3	(lb/in.)
(4)	Blade Segment No. 4	(lb/in.)
(5)	Blade Segment No. 5	(lb/in.)
(6)	Blade Segment No. 6	(lb/in.)
(7)	Blade Segment No. 7	(lb/in.)

CARD 81/A2

XTW (8)	Blade Segment No. 8	(lb/in.)
(9)	Blade Segment No. 9	(lb/in.)
(10)	Blade Segment No. 10	(lb/in.)
(11)	Blade Segment No. 11	(lb/in.)
(12)	Blade Segment No. 12	(lb/in.)
(13)	Blade Segment No. 13	(lb/in.)
(14)	Blade Segment No. 14	(lb/in.)

CARD 81/A3

XTW(15)	Blade Segment No. 15	(lb/in.)
(16)	Blade Segment No. 16	(lb/in.)
(17)	Blade Segment No. 17	(lb/in.)
(18)	Blade Segment No. 18	(lb/in.)
(19)	Blade Segment No. 19	(lb/in.)
(20)	Blade Segment No. 20	(lb/in.)
(21)	Tip Weight	(lb)

2.10.2 Average Running Beamwise Mass Moment of Inertia of Blade Segment

CARD 81/B1

XTW(22)	Blade Segment No. 1 (root)	(in.-lb-sec^2/in.)
(23)	Blade Segment No. 2	(in.-lb-sec^2/in.)
(24)	Blade Segment No. 3	(in.-lb-sec^2/in.)
(25)	Blade Segment No. 4	(in.-lb-sec^2/in.)

(26)	Blade Segment No. 5	(in.-lb-sec^2/in.)
(27)	Blade Segment No. 6	(in.-lb-sec^2/in.)
(28)	Blade Segment No. 7	(in.-lb-sec^2/in.)

CARD 81/B2

XTW(29)	Blade Segment No. 8	(in.-lb-sec^2/in.)
(30)	Blade Segment No. 9	(in.-lb-sec^2/in.)
(31)	Blade Segment No. 10	(in.-lb-sec^2/in.)
(32)	Blade Segment No. 11	(in.-lb-sec^2/in.)
(33)	Blade Segment No. 12	(in.-lb-sec^2/in.)
(34)	Blade Segment No. 13	(in.-lb-sec^2/in.)
(35)	Blade Segment No. 14	(in.-lb-sec^2/in.)

CARD 81/B3

XTW(36)	Blade Segment No. 15	(in.-lb-sec^2/in.)
(37)	Blade Segment No. 16	(in.-lb-sec^2/in.)
(38)	Blade Segment No. 17	(in.-lb-sec^2/in.)
(39)	Blade Segment No. 18	(in.-lb-sec^2/in.)
(40)	Blade Segment No. 19	(in.-lb-sec^2/in.)
(41)	Blade Segment No. 20	(in.-lb-sec^2/in.)
(42)	Currently unused	

2.10.3 Average Running Chordwise Mass Moment of Inertia of Blade Segment

CARD 81/C1

XTW(43)	Blade Segment No. 1 (root)	(in.-lb-sec^2/in.)
(44)	Blade Segment No. 2	(in.-lb-sec^2/in.)
(45)	Blade Segment No. 3	(in.-lb-sec^2/in.)
(46)	Blade Segment No. 4	(in.-lb-sec^2/in.)
(47)	Blade Segment No. 5	(in.-lb-sec^2/in.)
(48)	Blade Segment No. 6	(in.-lb-sec^2/in.)
(49)	Blade Segment No. 7	(in.-lb-sec^2/in.)

CARD 81/C2

XTW(50)	Blade Segment No. 8	(in.-lb-sec^2/in.)
(51)	Blade Segment No. 9	(in.-lb-sec^2/in.)
(52)	Blade Segment No. 10	(in.-lb-sec^2/in.)
(53)	Blade Segment No. 11	(in.-lb-sec^2/in.)
(54)	Blade Segment No. 12	(in.-lb-sec^2/in.)
(55)	Blade Segment No. 13	(in.-lb-sec^2/in.)
(56)	Blade Segment No. 14	(in.-lb-sec^2/in.)

CARD 81/C3

XTW(57)	Blade Segment No. 15	(in.-lb-sec^2/in.)
(58)	Blade Segment No. 16	(in.-lb-sec^2/in.)
(59)	Blade Segment No. 17	(in.-lb-sec^2/in.)
(60)	Blade Segment No. 18	(in.-lb-sec^2/in.)
(61)	Blade Segment No. 19	(in.-lb-sec^2/in.)
(62)	Blade Segment No. 20	(in.-lb-sec^2/in.)
(63)	Currently unused	

2.10.4 Average Beamwise Center of Gravity Offset of Blade Segment

CARD 81/D1

XTW(64)	Blade Segment No. 1 (root)	(in.)
(65)	Blade Segment No. 2	(in.)
(66)	Blade Segment No. 3	(in.)
(67)	Blade Segment No. 4	(in.)
(68)	Blade Segment No. 5	(in.)
(69)	Blade Segment No. 6	(in.)
(70)	Blade Segment No. 7	(in.)

CARD 81/D2

XTW(71)	Blade Segment No. 8	(in.)
(72)	Blade Segment No. 9	(in.)
(73)	Blade Segment No. 10	(in.)
(74)	Blade Segment No. 11	(in.)
(75)	Blade Segment No. 12	(in.)
(76)	Blade Segment No. 13	(in.)
(77)	Blade Segment No. 14	(in.)

CARD 81/D3

XTW(78)	Blade Segment No. 15	(in.)
(79)	Blade Segment No. 16	(in.)
(80)	Blade Segment No. 17	(in.)
(81)	Blade Segment No. 18	(in.)
(82)	Blade Segment No. 19	(in.)
(83)	Blade Segment No. 20	(in.)
(84)	cg offset of tipweight	(in.)

2.10.5 Average Chordwise Center of Gravity Offset of Blade Segment

CARD 81/E1

XTW(85)	Blade Segment No. 1 (root)	(in.)
(86)	Blade Segment No. 2	(in.)

(87)	Blade Segment No. 3	(in.)
(88)	Blade Segment No. 4	(in.)
(89)	Blade Segment No. 5	(in.)
(90)	Blade Segment No. 6	(in.)
(91)	Blade Segment No. 7	(in.)

CARD 81/E2

XTW(92)	Blade Segment No. 8	(in.)
(93)	Blade Segment No. 9	(in.)
(94)	Blade Segment No. 10	(in.)
(95)	Blade Segment No. 11	(in.)
(96)	Blade Segment No. 12	(in.)
(97)	Blade Segment No. 13	(in.)
(98)	Blade Segment No. 14	(in.)

CARD 81/E3

XTW(99)	Blade Segment No. 15	(in.)
(100)	Blade Segment No. 16	(in.)
(101)	Blade Segment No. 17	(in.)
(102)	Blade Segment No. 18	(in.)
(103)	Blade Segment No. 19	(in.)
(104)	Blade Segment No. 20	(in.)
(105)	cg offset of tipweight	(in.)

2.10.6 Blade Mode Shape Data

The IPL(7) elastic mode shapes for Rotor 2 are input here. Each mode shape is input on (|IPL(5)| +5) cards. The format for all the cards in a mode shape is 6F10.0. In the following discussion, MN is the mode shape number ($\leq$IPL(7)).

2.10.6.1 First Mode (MN = 1)

CARD 82/A1 Blade General Mode Shape Data

XGMS	(1,MN+IPL(6))*	Mode type indicator	
	(2,MN+IPL(6))	Natural frequency	(/rev)
	(3,MN+IPL(6))	Generalized inertia	(slug-ft^2)
	(4,MN+IPL(6))	Modal damping ratio	
	(5,MN+IPL(6))	Inplane hub shear coefficient	(lb)
	(6,MN+IPL(6))	Out-of-plane hub shear coefficient	(lb)

*The second subscript is MN+IPL(6) because the general mode shape data for Rotor 2 are stored in the XGMS array after the general mode shape data for Rotor 1.

CARD 82/A2

XGMS	(7,MN+IPL(6))	Pitch-Link Load Coefficient	(lb)	
	(8,MN+IPL(6))	Lag Angle	(deg)	
	(9,MN+IPL(6))	Reference RPM	(rpm)	
	(10,MN+IPL(6))	Reference Collective	(deg)	
	(11,MN+IPL(6))	Pitch bearing out-of-plane slope	(deg)	*
	(12,MN+IPL(6))	Pitch bearing inplane slope	(deg)	*

CARD 82/A3

XGMS	(13,MN+IPL(6))	Integral of (OP component) x (r)dm	(slug-ft^2)	
	(14,MN+IPL(6))	Integral of (OP component)dm	(slug-ft)	
	(15,MN+IPL(6))	Integral of (IP component) x (r)dm	(slug-ft^2)	
	(16,MN+IPL(6))	Integral of (IP component)dm	(slug-ft)	
	(17,MN+IPL(6))	Pitch bearing out-of-plane displacement	(ft)	*
	(18,MN+IPL(6))	Pitch bearing inplane displacement	(ft)	*

CARD 82/B1 Blade Mode Shape

Mode Shape Data at Station No. 0 (Center of Rotation)

(1)	Out-of-plane displacement	(ft)
(2)	Inplane displacement	(ft)
(3)	Torsional displacement	(deg)
(4)	Out-of-plane bending moment coefficient	(ft-lb)
(5)	Inplane bending moment coefficient	(ft-lb)
(6)	Torsional moment coefficient	(ft-lb)

CARD 82/B2 Blade Mode Shape Data at Station No. 1 (XTBS(1))

(7)	Out-of-plane displacement	(ft)
(8)	Inplane displacement	(ft)
(9)	Torsional displacement	(deg)
(10)	Out-of-plane bending moment coefficient	(ft-lb)
(11)	Inplane bending moment coefficient	(ft-lb)
(12)	Torsional moment coefficient	(ft-lb)

CARD 82/B3
CARD 82/B4
etc.

Format repeated until there are (|IPL(5)| +1) cards, one for each station

CARD 82/C1 Cyclic Detuning Data

(1)	Natural frequency at low rpm and low pitch angle	(cpm)
(2)	Natural frequency at low rpm and high pitch angle	(cpm)
(3)	Natural frequency at high rpm and low pitch angle	(cpm)
(4)	Natural frequency at high rpm and high pitch angle	(cpm)
(5)	Difference between reference pitch angle and high or low value	(deg)
(6)	Difference between reference rpm and either high or low value	(rpm)

2.10.6.2 Second and Subsequent Blade Modes

CARDS 83/A1 through 83/C1 (Include only if IPL(7)$\geq$2) (MN = 2)

Input sequence and format similar to that of blade Mode 1.

CARDS 84/A1 through 84/C1 (Include only if IPL(7)$\geq$3) (MN = 3)

Input sequence and format similar to that of blade Mode 1.

.
.
.

CARDS 8C/A1 through 8C/C1 (Include only if IPL(7)=11) (MN = 11)

Input sequence and format similar to that of Mode 1.

2.11 ROTOR AERODYNAMIC GROUP (omit only if IPL(3) = 3 and IPL(11) = 0)

CARD 90 Rotor Aerodynamic Group Identification Card

2.11.1 Rotor Airfoil Aerodynamic (RAA) Subgroup No. 1

CARD 91A

YRR	(1,1)	Drag divergence Mach number for $\alpha = 0$	
	(2,1)	Mach number for lower boundary of supersonic region	
	(3,1)	Maximum C_L, normal flow, $M = 0$	
	(4,1) (5,1) (6,1)	Coefficients of Mach number in maximum C_L equation, normal flow	
	(7,1)	Maximum C_L, reversed flow, $M = 0$	

CARD 91B

YRR	(8,1)	Slope of lift curve for $M = 0$	(/deg)
	(9,1)	Coefficients of M for	(/deg)
	(10,1)	lift-curve slope in sub-	(/deg)
	(11,1)	sonic region	(/deg)
	(12,1)	C_D for $\alpha = 0$, $M = 0$	
	(13,1)	Coefficients of α in non-	(/deg)
	(14,1)	divergent drag equation	(/deg^2)

CARD 91C

YRR	(15,1)	Coefficient in supersonic drag equation	
	(16,1)	Maximum nondivergent C_D	
	(17,1)	Thickness/chord ratio	
	(18,1)	Control variable for using data table (=0.0, uses equations: >0, uses YRR(18,1)th table - internal 0012 table is Table 10)	
	(19,1)	Drag rise coefficient	(/deg)
	(20,1)	Coefficient of yaw angle in Mach number equation	
	(21,1)	Exponent in Mach number equation for yawed flow	

CARD 91D

YRR	(22,1)	Coefficients of α for Mach	(/deg2)
	(23,1)	critical in steady C_M	(/deg)
	(24,1)	equation	
	(25,1)	C_M for $\alpha = 0$, $M = 0$	
	(26,1)		

	(27,1)	Switch for UNSAN yawed flow effects (0 = off)	
	(28,1)	Maximum value of yawed flow angle	(deg)

CARD 91E

YRR	(29,1)	Zero lift line orientation at M = 0, normal flow	(deg)
	(30,1)	Coefficients for zero lift line orientation as a function of Mach number	(deg)
	(31,1)		(deg)
	(32,1)		
	(33,1)	Increment to steady state lift coefficient	
	(34,1)	Incr·ment to steady state drag coefficient	
	(35,1)	Increment to steady state pitching moment coefficient	

2.11.2 RAA Subgroup No. 2 (Include only if IPL(11)$\geq$2)

CARD 92A
CARD 92B
CARD 92C YRR(1,2)→YRR(35,2)
CARD 92D
CARD 92E

2.11.3 RAA Subgroup No. 3 (Include only if IPL(11)$\geq$3)

CARD 93A
CARD 93B
CARD 93C YRR(1,3)→YRR(35,3)
CARD 93D
CARD 93E

2.11.4 RAA Subgroup No. 4 (Include only if IPL(11)$\geq$4)

CARD 94A
CARD 94B
CARD 94C YRR(1,4)→YRR(35,4)
CARD 94D
CARD 94E

2.11.5 RAA Subgroup No. 5 (Include only if IPL(11) $\geq$ 5)

CARD 95A
CARD 95B
CARD 95C YRR(1,5)→YRR(35,5)
CARD 95D
CARD 95E

2.11.6 RAA Subgroup No. 6 (Include only if IPL(11) $\geq$ 6) +

CARD 96A
CARD 96B
CARD 96C YRR(1,6)→YRR(35,6)
CARD 96D
CARD 96E

2.11.7 RAA Subgroup No. 7 (Include only if IPL(11) $\geq$ 7) +

CARD 97A
CARD 97B
CARD 97C YRR(1,7)→YRR(35,7)
CARD 97D
CARD 97E

2.11.8 RAA Subgroup No. 8 (Include only if IPL(11) $\geq$ 8) +

CARD 98A
CARD 98B
CARD 98C YRR(1,8)→YRR(35,8)
CARD 98D
CARD 98E

2.11.9 RAA Subgroup No. 9 (Include only if IPL(11) $\geq$ 9) +

CARD 99A
CARD 99B
CARD 99C YRR(1,9)→YRR(35,9)
CARD 99D
CARD 99E

2.11.10 RAA Subgroup No. 10 (Include only if IPL(11) = 10) +

CARD 9AA
CARD 9AB
CARD 9AC YRR(1,10)→YRR(35,10)
CARD 9AD
CARD 9AE

+ New Group

2.12 <u>ROTOR INDUCED VELOCITY DISTRIBUTION TABLES GROUP</u> (omit if IPL(12) = 0)

A rotor induced velocity distribution (RIVD) table may be input for each rotor. If a table is not input for a particular rotor, the distribution is computed from the equation in Section 4.12.3.

2.12.1 <u>Rotor 1 Table</u> (include only if IPL(12) = 1 or 3)

CARD 100 Rotor 1 RIVD Table Identification Card

CARD 100/A Title and Control Card (8A4, 8X, 4I3, 8X, F10.0 format)

Col 1-32 Alphanumeric title for table
41-43 NMU, Number of advance ratios ($1 \leq$ NMU ≤ 3)

44-46 NLM, Number of inflow ratios ($1 \leq$ NLM ≤ 2)

47-49 NHH, Order of highest harmonic ($0 \leq$ NHH ≤ 6)

50-52 NRS, Number of radial stations (if input as 0, defaults to radial stations given in main rotor group) (NRS ≤ 20)

2.12.1.1 <u>Advance Ratio Inputs</u>

CARD 100/B (include only if NMU $\geq$ 2; 7F10.0 format)

WKMU (1) Smallest advance ratio
(2) Next larger advance ratio
(3) Next larger advance ratio
(4)
(5)
(6)
(7)
Currently unused

2.12.1.2 <u>Inflow Ratio Inputs</u>

CARD 100/C (include only if NLM = 2; 5F10.0 format)

WKLM (1) Smallest inflow ratio
(2) Next larger inflow ratio
(3)
(4)
(5)
(6)
(7)
Currently unused

2.12.1.3 Radial Station Inputs

CARD 100/D (Include only if NRS ≠ 0, 7F10.0 format)

WKRS (1)	Radius to RIVD Table Station 1	(in.)
(2)	Radius to RIVD Table Station 2	(in.)
(3)	Radius to RIVD Table Station 3	(in.)
(4)	Radius to RIVD Table Station 4	(in.)
(5)	Radius to RIVD Table Station 5	(in.)
(6)	Radius to RIVD Table Station 6	(in.)
(7)	Radius to RIVD Table Station 7	(in.)

CARD 100/E (Include only if NRS ≠ 0, 7F10.0 format)

WKRS (8)	Radius to RIVD Table Station 8	(in.)
(9)	Radius to RIVD Table Station 9	(in.)
(10)	Radius to RIVD Table Station 10	(in.)
(11)	Radius to RIVD Table Station 11	(in.)
(12)	Radius to RIVD Table Station 12	(in.)
(13)	Radius to RIVD Table Station 13	(in.)
(14)	Radius to RIVD Table Station 14	(in.)

CARD 100/F (Include only if NRS ≠ 0, 7F10.0 format)

WKRS(15)	Radius to RIVD Table Station 15	(in.)
(16)	Radius to RIVD Table Station 16	(in.)
(17)	Radius to RIVD Table Station 17	(in.)
(18)	Radius to RIVD Table Station 18	(in.)
(19)	Radius to RIVD Table Station 19	(in.)
(20)	Radius to RIVD Table Station 20	(in.)
(21)	Currently unused	

NOTE: All three cards (CARD 100/D, CARD 100/E and CARD 100/F) must be included if NRS ≠ 0.0. Station 1 must not be at the center of rotation, but should be the inner-most RIVD station. These cards must not be included if NRS = 0.

2.12.1.4 Sets of Coefficients (NMU*NLM*NRS sets required)

Each set of coefficients corresponds to a specific combination of advance ratio, inflow ratio, and radial station (WKMU(I), WKLM(J), and WKRS(K) respectively). See Figure 19 for input

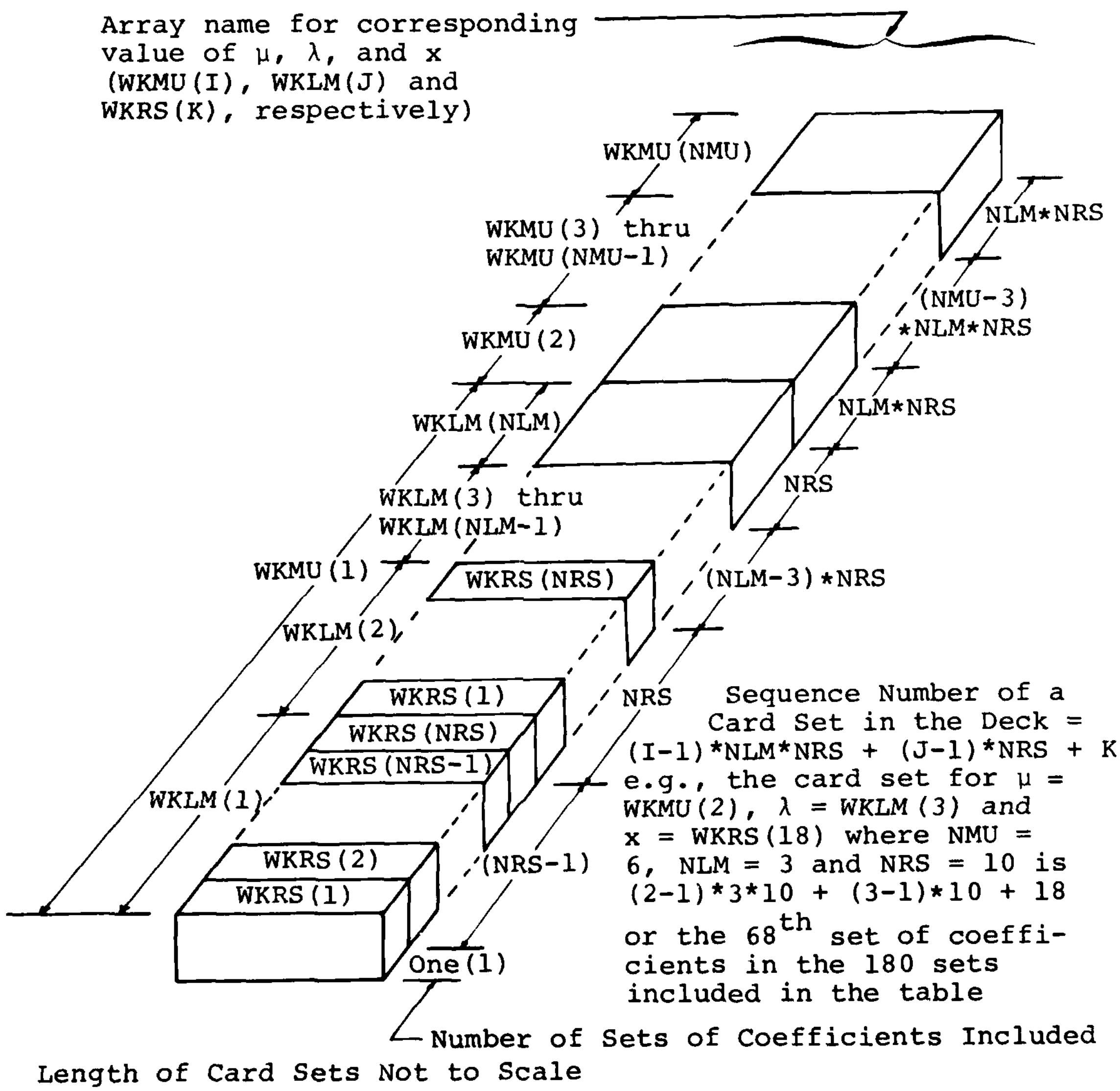


Figure 19. Schematic of Card Deck for RIVD Table.

sequence of the sets. Each set of coefficients starts on a new card and consists of one to six cards in the following format:

First Card (7F10.0 format)

Col	1-10	Constant (zeroth harmonic)
	11-20	Sine component of first harmonic
	21-30	Cosine component of first harmonic
	31-40	Sine component of second harmonic
	41-50	Cosine component of second harmonic
	51-60	Sine component of third harmonic
	61-70	Cosine component of third harmonic

Second Card (include only if NHH $\geq$ 4; 10X, 6F10.0 format)

Col	1-10	(Not used)
	11-20	Sine component of fourth harmonic
	21-30	Cosine component of fourth harmonic
	31-40	Sine component of fifth harmonic
	41-50	Cosine component of fifth harmonic
	51-60	Sine component of sixth harmonic
	61-70	Cosine component of sixth harmonic

2.12.2 Rotor 2 Table (include only if IPL(12) = 2 or 3) +

Format for this table is the same as for the Rotor 1 Table.

CARD 110	Rotor 2 RIVD Table Identification Card
CARD 110/A	Title and Control Card
CARD 110/B1 CARD 110/B2	Advance ratio inputs
CARD 110/C	Inflow ratio inputs

Sets of Coefficients

Rotor 2 RIVD coefficients are input in the same format as those for Rotor 1 (Section 2.12.1). There will be NMU*NLM*NRS sets of up to two cards each, plus NMU cards containing the average induced velocities.

+ Order of highest harmonic now limited to 6.

2.13 ROTOR WAKE AT AERODYNAMIC SURFACES TABLES GROUP (Omit if IPL(13) = 0)

If IPL(13) ≠ 0, exactly IPL(13) tables must be input. The formats for all tables are identical and similar to the RIVD tables discussed in Section 2.12. The format for an example table follows:

First Card: Table Identification Card

Second Card: Title and Control Card (8A4, 8X, 3I3 format)

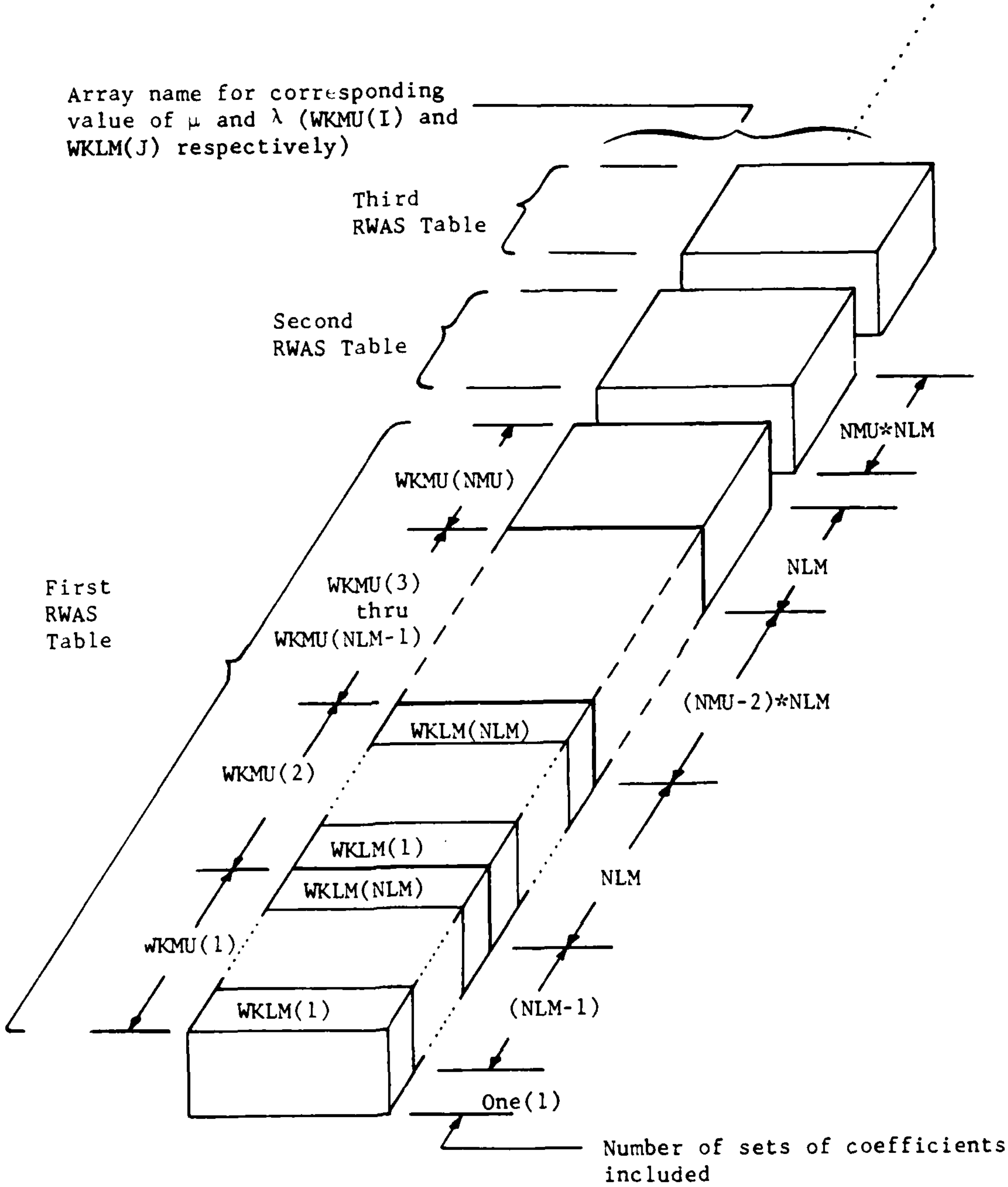
Col	1-32	Alphanumeric title for table
	41-43	NMU, Number of advance ratios ($1 \leq NMU \leq 3$)
	44-46	NLM, Number of inflow ratios ($1 \leq NLM \leq 2$)
	47-49	NHH, Order of highest harmonic ($0 \leq NHH \leq 1$) *

Next Card: Advance ratio inputs; 3F10.0 format; include if and only if $NMU \geq 2$

Next Card: Inflow ratio inputs; 2F10.0 format; include if and only if NLM = 2

Next Cards: Set of coefficients; NMU*NLM sets required; one card for each set since NHH ≤ 1; same format as for sets of coefficients in RIVD Tables (see Section 2.10.1.3); see Figure 20 for input sequence of the sets. +

+ Order of highest harmonic now limited to 1.



Length of Card Sets Not to Scale

Figure 20. Schematic of Card Deck for a Set of RWAS Tables.

2.14 BASIC FUSELAGE GROUP (include only if IPL(1) ≤9)

CARD 120 Basic Fuselage Group Identification Card

CARD 121

XFS	(1)	Gross weight		(lb)
	(2)	Stationline	Location of fuselage data reference point	(in.)
	(3)	Buttline		(in.)
	(4)	Waterline		(in.)
	(5)	Stationline	Location of center of gravity	(in.)
	(6)	Buttline		(in.)
	(7)	Waterline		(in.)

CARD 122

XFS	(8)	Aircraft rolling inertia, I_{xx}	(slug-ft^2)	
	(9)	Aircraft pitching inertia, I_{yy}	(slug-ft^2)	
	(10)	Aircraft yawing inertia, I_{zz}	(slug-ft^2)	
	(11)	Aircraft product of inertia, I_{xz}	(slug-ft^2)	
	(12)	Force and moment equation use indicator, LFG		
	(13)	Phasing Angle (Nominal/Phasing)	(deg)	
	(14)	Phasing Angle (High/Phasing)	(deg)	+

CARD 123 ++

XFS	(15)	$\Delta\alpha_{\text{Lift}}$	(deg)
	(16)	$\Delta\alpha_{\text{Drag}}$	(deg)
	(17)	$\Delta\alpha_{\text{Pitching Moment}}$	(deg)
	(18)	$\Delta\psi_{\text{Side Force}}$	(deg)
	(19)	$\Delta\psi_{\text{Yawing Moment}}$	(deg)
	(20)	$\Delta\psi_{\text{Rolling Moment}}$	(deg)
	(21)	Currently unused	

CARD 124 ++

XFS	(22)	$\Delta\psi_{\text{Lift}}$	(deg)
	(23)	$\Delta\psi_{\text{Drag}}$	(deg)
	(24)	$\Delta\psi_{\text{Pitching Moment}}$	(deg)
	(25)	$\Delta\alpha_{\text{Side Force}}$	(deg)

\+ Fuselage aerodynamic data moved to separate group
++ New cards

	(26)	$\Delta\alpha_{\text{Yawing Moment}}$	(deg)	
	(27)	$\Delta\alpha_{\text{Rolling Moment}}$	(deg)	
	(28)	Currently unused		

CARD 125

XFS	(29)	Δ Lift/q	(ft^2)	+
	(30)	Δ Drag/q	(ft^2)	
	(31)	Δ Pitching Moment/q	(ft^3)	
	(32)	Δ Side Force/q	(ft^2)	
	(33)	Δ Yawing Moment/q	(ft^3)	
	(34)	Δ Rolling Moment/q	(ft^3)	
	(35)	Currently unused		

+ New card

2.15 FUSELAGE AERODYNAMIC GROUP +

The aerodynamics of the fuselage can be represented either by a set of equations (IPL(29) = 0) or a set of tables (IPL(29) ≠ 0).

2.15.1 FUSELAGE AERODYNAMIC EQUATION GROUP (include only if IPL(1) $\leq$ 9 and IPL(29) = 0)

CARD 130 Fuselage Aerodynamic Equation Group Identification Card

Cards 131 through 13C contain the coefficients for the High Angle and Nominal Angle Equations. The asterisk (*) indicates that the input is considered necessary (see Section 4.15.1). The forces and moments computed from the equations are in the wind-axis coordinate system.

CARD 131

YFS	*(1)	L/q at $\psi_W = \theta_W = 0°$ (Fwd Flt)	(ft^2)
	(2)	L/q at $\psi_W = 180°$, $\theta_W = 0°$ (Rwd Flt)	(ft^2)
	(3)	Approx. peak L/q for $0° \leq \theta_W \leq 90°$, $\psi_W = 0°$	(ft^2)
	(4)	Value of θ_W for YFS(3)	(deg)
	(5)	L/q at $\psi_W = 0°$, $\theta_W = 90°$ (Vert Flt)	(ft^2)
	(6)	L/q at $\psi_W = 90°$, $\theta_W = 0°$ (Sideward Flt)	(ft^2)
	(7)	$\partial(L/q)/\partial\psi_W$	(ft^2/deg)

CARD 132

YFS	(8)	$\partial(L/q)/\mu(\psi_W^2)$	(ft^2/deg^2)
	*(9)	$\partial(L/q)/\partial\theta_W$; lift-curve slope at $\psi_W = 0°$	(ft^2/deg)
	(10)	$\partial(\partial(L/q)/\partial\psi_W)/\partial\theta_W$	(ft^2/deg^2)
	(11)	$\partial(\partial(L/q)/\partial(\psi_W^2))/\partial\theta_W$	(ft^2/deg^3)
	(12)	$\partial(L/q)/\partial(\theta_W^2)$	(ft^2/deg^2)
	(13)	$\partial(\partial(L/q)/\partial\psi_W)/\partial(\theta_W^2)$	(ft^2/deg^3)
	(14)	$\partial(L/q)\partial(\theta_W^3)$	(ft^2/deg^3)

+ New Group, cards moved from Basic Fuselage Group

CARD 133

YFS	*(15)	D/q at $\psi_w = \theta_w = 0°$ (Fwd Flt)	(ft^2)
	(16)	D/q at $\psi_w = 180°$, $\theta_w = 0°$ (Rwd Flt)	(ft^2)
	(17)	D/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^2)
	(18)	D/q at $\theta_w = -90°$ (Ascending Vertical Flt)	(ft^2)
	(19)	D/q at $\theta_w = +90°$ (Descending Vertical Flt)	(ft^2)
	(20)	Currently unused	
	(21)	$\partial(D/q)/\partial\psi_w$	(ft^2/deg)

CARD 134

YFS	*(22)	$\partial(D/q)/\partial(\psi_w^2)$; variation of drag with ψ_w^2 at $\theta_w = 0°$	)ft^2/deg^2)
	*(23)	$\partial(D/q)/\partial\theta_w$; variation of drag with θ_w at $\psi_w = 0°$	(ft^2/deg)
	(24)	$\partial(\partial(D/q)/\partial\psi_w)/\partial\theta_w$	(ft^2/deg^2)
	(25)	$\partial(\partial(D/q)/\partial(\psi_w^2))/\partial\theta_w$	(ft^2/deg^3)
	*(26)	$\partial(D/q)/\partial(\theta_w^2)$; variation of drag with θ_w^2 at $\psi = 0°$	(ft^2/deg^2)
	(27)	$\partial(\partial D/q)/\partial\psi_w)/\partial(\theta_w^2)$	(ft^2/deg^3)
	(28)	$\partial(D/q)/\partial(\theta_w^3)$	(ft^2/deg^3)

CARD 135

YFS	*(29)	M/q at $\psi_w = \theta_w = 0°$ (Fwd Flt)	(ft^3)
	(30)	M/q at $\psi_w = 180°$, $\theta_w = 0°$ (Rwd Flt)	(ft^3)
	(31)	Approx. peak M/q for $0° \leq \theta_w \leq 90°$, $\psi_w = 0°$	(ft^3)
	(32)	Value of θ_w for YFS(31)	(deg)
	(33)	M/q at $\psi_w = 0°$, $\theta_w = 90°$ (Vertical Flt)	(ft^3)
	(34)	M/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^3)
	(35)	$\partial(M/q)\partial\psi_w$	(ft^3/deg)

CARD 136

YFS	(36)	$\partial(M/q)/\partial(\psi_w^2)$	(ft^2/deg^3)
	*(37)	$\partial(M/q)/\partial\theta_w$; static longitudinal stability	(ft^3/deg)
	(38)	$\partial(\partial(M/q)/\partial\psi_w)/\partial\theta_w$	(ft^3/deg^2)
	(39)	$\partial(\partial(M/q)/\partial(\psi_w^2))/\partial\theta_w$	(ft^3/deg^3)
	(40)	$\partial(M/q)/\partial(\theta_w^2)$	(ft^3/deg^2)
	(41)	$\partial(\partial(M/q)/\partial\psi_w)/\partial(\theta_w^2)$	(ft^3/deg^3)
	(42)	$\partial(M/q)/\partial(\theta_w^3)$	(ft^3/deg^3)

CARD 137

YFS	(43)	Y/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^2)
	(44)	Approx. peak Y/q for $0 \le \psi_w \le 90°$, $\theta_w = 0°$	(ft^2)
	(45)	Value of ψ_w for YFS(44)	(deg)
	(46)	Y/q at $\psi_w = \theta_w = 0°$ (Fwd Flt)	(ft^2)
	(47)	$\partial(Y/q)/\partial\theta_w$	(ft^2/deg)
	(48)	$\partial(Y/q)/\partial(\theta_w^2)$	(ft^2/deg^2)
	(49)	$\partial(Y/q)/\partial(\theta_w^3)$	(ft^2/deg^3)

CARD 138

YFS	*(50)	$\partial(Y/q)/\partial\psi_w$; slope of Y versus ψ_w at $\theta_w = 0°$	(ft^2/deg)
	(51)	$\partial(\partial(Y/q)/\partial\theta_w)/\partial\psi_w$	(ft^2/deg^2)
	(52)	$\partial(\partial(Y/q)/\partial(\theta_w^2))/\partial\psi_w$	(ft^2/deg^3)
	(53)	$\partial(Y/q)/\partial(\psi_w^2)$	(ft^2/deg^2)
	(54)	$\partial(\partial(Y/q)/\partial\theta_w)/\partial(\psi_w^2)$	(ft^2/deg^3)
	(55)	$\partial(Y/q)/\partial(\psi_w^3)$	(ft^2/deg^3)
	(56)	$\partial(\partial(Y/q)/\partial\theta_w)/\partial(\psi_w^3)$	(ft^2/deg^4)

CARD 139

YFS	(57)	$1/q$ at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^3)
	(58)	Approx. peak $1/q$ for $0 \le \psi_w \le 90°$, $\theta_w = 0°$	(ft^3)
	(59)	Value of ψ_w for YFS(58)	(deg)
	(60)	$1/q$ at $\psi_w = \theta_w = 0°$ (Fwd. Flt.)	(ft^3)
	(61)	$\partial(1/q)/\partial\theta_w$	(ft^3/deg)
	(62)	$\partial(1/q)/\partial(\theta_w^2)$	(ft^3/deg^2)
	(63)	$\partial(1/q)/\partial(\theta_w^3)$	(ft^3/deg^3)

CARD 13A

YFS	*(64)	$\partial(1/q)/\partial\psi_w$; slope of RM curve for ψ_w at $\theta_w = 0°$	(ft^3/deg)
	(65)	$\partial(\partial(1/q)/\partial\theta_w)/\partial\psi_w$	(ft^3/deg^2)
	(66)	$\partial(\partial(1/q)/\partial(\theta_w^2)/\partial\psi_w$	(ft^3/deg^3)
	(67)	$\partial(1/q)/\partial(\psi_w^2)$	(ft^3/deg^2)
	(68)	$\partial(\partial(1/q)/\partial\theta_w)/\partial(\psi_w^2)$	(ft^3/deg^3)
	(69)	$\partial(1/q)/\partial(\psi_w^3)$	(ft^3/deg^3)
	(70)	$\partial(\partial(1/q)/\partial\theta_w)/\partial(\psi_w^3)$	(ft^3/deg^4)

CARD 13B

YFS	(71)	N/q at $\psi_w = 90°$, $\theta_w = 0°$ (Sideward Flt)	(ft^3)
	(72)	Approx. peak N/q for $0 \le \psi_w \le 90°$, $\theta_w = 0°$	(ft^3)
	(73)	Value of ψ_w for YFS(72)	(deg)
	(74)	N/q at $\psi_w = \theta_w = 0°$ (Fwd. Flt.)	(ft^3)
	(75)	$\partial(N/q)/\partial\theta_w$	(ft^3/deg)
	(76)	$\partial(N/q)/\partial(\theta_w^2)$	(ft^3/deg^2)
	(77)	$\partial(N/q)/\partial(\theta_w^3)$	(ft^3/deg^3)

CARD 13C

YFS	*(78)	$\partial(N/q)/\partial\psi_w$; slope of YM curve for ψ_w at $\theta_w = 0°$	(ft^3/deg)
	(79)	$\partial(\partial(N/q)/\partial\theta_w)/\partial\psi_w$	(ft^3/deg^2)
	(80)	$\partial(\partial(N/q)/\partial(\theta_w^2))/\partial\psi_w$	(ft^3/deg^3)
	(81)	$\partial(N/q)/\partial(\psi_w^2)$	(ft^3/deg^2)
	(82)	$\partial(\partial(N/q)/\partial\theta_w)/\partial(\psi_w^2)$	(ft^3/deg^3)
	(83)	$\partial(N/q)/\partial(\psi_w^3)$	(ft^3/deg^3)
	(84)	$\partial(\partial(N/q)/\partial\theta_w)/\partial(\psi_w^3)$	(ft^3/deg^4)

2.15.2 <u>FUSELAGE AERODYNAMIC TABLE GROUP (include only if IPL(1) ≤ 9 and IPL(29) ≠ 0)</u> +

CARD 130 Fuselage Aerodynamic Table Group Identification Card

The force and moment entries in the six subtables are the wind-axis fuselage forces and moments, normalized by the dynamic pressure.

CARD 131/A1 Title and Control Card

Col	1-30	Alphanumeric title for the table
	31-32	NFSYAW(1), number of aerodynamic yaw angle entries in the lift subtable
	33-34	NFSPCH(1), number of angle of attack entries in the lift subtable
	35-36	NFSYAW(2), number of aerodynamic yaw angle entries in the drag subtable
	37-38	NFSPCH(2), number of angle of attack entries in the drag subtable
	39-40	NFSYAW(3), number of aerodynamic yaw angle entries in the pitching moment subtable
	41-42	NFSPCH(3), number of angle of attack entries in the pitching moment subtable
	43-44	NFSPCH(4), number of angle of attack entries in the side force subtable
	45-46	NFSYAW(4), number of aerodynamic yaw angle entries in the side force subtable
	47-48	NFSPCH(5), number of angle of attack entries in the rolling moment subtable
	49-50	NFSYAW(5), number of aerodynamic yaw angle entries in the rolling moment subtable
	51-52	NFSPCH(6), number of angle of attack entries in the yawing moment subtable
	53-54	NFSYAW(6), number of aerodynamic yaw angle entries in the yawing moment subtable

2.15.2.1 <u>Fuselage Lift Subtable</u>

CARD 131/B1 Aerodynamic yaw angle entries for the fuselage lift table (7X, 9F7.0)

Col	8-14	ψ_{w_1}, smallest aerodynamic yaw angle, degrees
	15-21	ψ_{w_2}, next largest aerodynamic yaw angle
	22-28	ψ_{w_3}, next largest aerodynamic yaw angle

+ New Group

29-35 ψ_{w_4}, next largest aerodynamic yaw angle

36-42 ψ_{w_5}, next largest aerodynamic yaw angle

43-49 ψ_{w_6}, next largest aerodynamic yaw angle

50-56 ψ_{w_7}, next largest aerodynamic yaw angle

57-63 ψ_{w_8}, next largest aerodynamic yaw angle

64-70 ψ_{w_9}, next largest aerodynamic yaw angle

$$\psi_{w_1} < \psi_{w_2} < \psi_{w_3} < \psi_{w_4} < \psi_{w_5} < \psi_{w_6} < \psi_{w_7} < \psi_{w_8} < \psi_{w_9}$$

CARD 131/B2 Additional aerodynamic yaw angles (include only if NFSYAW(1) $\geq$ 10)

This card contains additional aerodynamic yaw angles at which table entries are defined, in ascending order, using the same format as CARD 131/B1. Include additional CARDs 131/B2 until NFSYAW(1) aerodynamic yaw angles have been input.

CARD 131/C1 Fuselage Lift Cards

NFSPCH(1) sets of cards follow the aerodynamic yaw cards. These sets of cards contain the angle of attack, in ascending order, and the lift entries, as follows:

First Card

Col	1-7	Angle of attack, degrees	
	8-14	Lift/q at $\psi_w = \psi_{w_1}$	(ft^2)
	15-21	Lift/q at $\psi_w = \psi_{w_2}$	(ft^2)
	22-28	Lift/q at $\psi_w = \psi_{w_3}$	(ft^2)
	29-35	Lift/q at $\psi_w = \psi_{w_4}$	(ft^2)
	36-42	Lift/q at $\psi_w = \psi_{w_5}$	(ft^2)
	43-49	Lift/q at $\psi_w = \psi_{w_6}$	(ft^2)
	50-56	Lift/q at $\psi_w = \psi_{w_7}$	(ft^2)
	57-63	Lift/q at $\psi_w = \psi_{w_8}$	(ft^2)
	64-70	Lift/q at $\psi_w = \psi_{w_9}$	(ft^2)

Second Card (Include only if NFSYAW(1) $\geq$ 10)

Col	1-7	Not used	
	8-14	Lift/q at $\psi_w = \psi_{w_{10}}$	(ft^2)
	15-21	Lift/q at $\psi_w = \psi_{w_{11}}$	(ft^2)
	21-28	Lift/q at $\psi_w = \psi_{w_{12}}$	(ft^2)
	29-35	Lift/q at $\psi_w = \psi_{w_{13}}$	(ft^2)
	35-42	Lift/q at $\psi_w = \psi_{w_{14}}$	(ft^2)
	43-49	Lift/q at $\psi_w = \psi_{w_{15}}$	(ft^2)
	50-56	Lift/q at $\psi_w = \psi_{w_{16}}$	(ft^2)
	57-63	Lift/q at $\psi_w = \psi_{w_{17}}$	(ft^2)
	64-70	Lift/q at $\psi_w = \psi_{w_{18}}$	(ft^2)

Third Card (Include only if NFSYAW(1) $\geq$ 19)

This card contains the values of the lift (divided by dynamic pressure) for $\psi_w=\psi_{w_{19}}$ through $\psi_w=\psi_{w_{27}}$, in the same format as the Second Card of the set, (7X, 9F7.0).

2.15.2.2 Fuselage Drag Subtable

The Fuselage Drag Subtable is input in a format identical to that of the Fuselage Lift Subtable. The dimension of D/q is ft^2.

2.15.2.3 Fuselage Pitching Moment Subtable

The Fuselage Pitching Moment Subtable is input in a format identical to that of the Fuselage Lift Subtable. The dimension of M/q is ft^3.

2.15.2.4 Fuselage Side Force Subtable

The Fuselage Side Force Subtable is input in a format identical to that of the Fuselage Lift Subtable, with the angles of attack all input on CARD 131/H1 (and 131/H2 if NFSPCH(4)$\geq$10). The aerodynamic yaw angles are input on the 131/I-types cards, with the (side force)/(dynamic pressure) entries. The dimension of the Y/q inputs is ft^2.

2.15.2.5 Fuselage Rolling Moment Subtable

The Fuselage Rolling Moment Subtable is input in a format identical to that of the Fuselage Side Force Subtable. The angles of attack are all input on CARD 131/J1 (and 131/J2 if NFSPCH(5) $\geq$ 10). The aerodynamic yaw angles are input on the 131/K-type cards, with the (rolling moment)/(dynamic pressure) entries. The dimension of the ℓ/q inputs is ft^3.

2.15.2.6 Fuselage Yawing Moment Subtable

The Fuselage Yawing Moment Subtable is input in a format identical to that of the Fuselage Side Force and Fuselage Rolling Moment Subtables. The dimension of the N/q inputs is ft^3.

2.16 WING GROUP (omit if IPL(15) = 0 or IPL(1) > 9)

CARD 140 Wing Group Identification Card

2.16.1 Basic Inputs

CARD 141

XWG	(1)	Wing area (including carry-through)	(ft^2)
	(2)	Stationline } Location of center of	(in.)
	(3)	Buttline } pressure for right	(in.)
	(4)	Waterline } wing panel	(in.)
	(5)	Incidence angle (+ nose up)	(deg)
	(6)	Effective dihedral angle (+ up)	(deg)
	(7)	Sweep angle of quarter chord line (+ aft)	(deg)

CARD 142

XWG	(8)	Geometric aspect ratio	
	(9)	Spanwise efficiency factor	
	(10)	Taper ratio of wing (tip chord/root chord)	
	(11)	Coefficient in equation for dynamic pressure reduction at stabilizers due to wing	
	(12)	Dynamic pressure reduction at wing due to fuselage	
	(13)	Coefficient in equation for wing wake centerline deflection	(deg)
	(14)	Control surface (flap) deflection	(deg)

CARD 143

XWG	(15)	Coefficients for change in lift coefficient as a function of control	(deg)
	(16)	surface deflection	($/deg^2$)
	(17)	Coefficients for change in maximum lift coefficient as a function of	(/deg)
	(18)	control surface deflection	($/deg^2$)
	(19)	Coefficients for change in profile drag coefficient as a function of	(/deg)
	(20)	control surface deflection	($/deg^2$)
	(21)	Currently unused	

CARD 144

XWG	(22)	Coefficients for change in wing pitching moment as a function of control surface deflection	(/deg)
	(23)		($/deg^2$)
	(24)	Coefficients for downwash at the right wing panel due to the fuselage	(/deg)
	(25)		(deg/deg)
	(26)		(deg/deg^2)
	(27)	Coefficients for sidewash at the right wing panel due to fuselage	(deg/deg)
	(28)		(deg/deg^3)

CARD 145

XWG (29) Effect of Rotor 1 wake on R/H wing panel
(30) Effect of Rotor 1 wake on L/H wing panel
(31) Effect of Rotor 2 wake on L/H wing panel
(32) Effect of Rotor 2 wake on R/H wing panel
(33) Coefficient of sideslip in roll moment equation
(34) Coefficient of sideslip and C_L in roll moment equation
(35) Coefficient of yaw rate and C_L in roll moment equation

CARD 146

XWG (36) Coefficient of roll rate in roll moment equation
(37) Coefficient of sideslip in yaw moment equation
(38) Coefficient of sideslip and C_L^2 in yaw moment equation
(39) Coefficient of yaw rate and C_L^2 in yaw moment equation
(40) Coefficient of yaw rate and C_{D_o} in yaw moment equation
(41) Coefficient of roll rate and C_L in yaw moment equation
(42) Coefficient of roll rate and $dC_D/d\alpha$ in yaw moment equation

2.16.2 Aerodynamic Inputs

CARD 147

YWG	(1)	Drag divergence Mach number for $\alpha = 0$	
	(2)	Mach number for lower boundary of supersonic region	
	(3)	Maximum C_L normal flow, M (Mach number) = 0	
	(4)	Coefficient of Mach number	
	(5)	in maximum C_L equation, normal	
	(6)	flow	
	(7)	Maximum C_L, reversed flow, M = 0	

CARD 148

YWG	(8)	Slope of lift curve for M = 0	(/deg)
	(9)	Coefficients of M for lift	(/deg)
	(10)	curve slope in subsonic	(/deg)
	(11)	region	(/deg)
	(12)	C_D for $\alpha = 0$, M = 0	
	(13)	Coefficients of α in a non-	(/deg)
	(14)	divergent drag equation	($/deg^2$)

CARD 149

YWG	(15)	Coefficient in supersonic drag equation	
	(16)	Maximum nondivergent C_D	
	(17)	Thickness/chord ratio	
	(18)	Control variable for use of data table	
	(19)	Drag rise coefficient	(/deg)
	(20)	Currently unused	
	(21)		

CARD 14A

YWG	(22)	Coefficients for α for	($/deg^2$)
	(23)	Mach Critical in steady C_M	(deg)
	(24)	equation	
	(25)	C_M for $\alpha = 0$, M = 0	
	(26)		
	(27)	Currently unused	
	(28)		

NOTE: The descriptions for the aerodynamic inputs for the stabilizing surfaces (YSTB1, YSTB2, YSTB3, and YSTB4 arrays) are identical to that for the YWG array.

2.16.3 <u>Control Linkage Inputs</u> (Include only if IPL(15)>0)

CARD 14B

XCWG	(1)	Coefficients for rigging wing angle to collective stick position	(deg/in.)
	(2)		(deg/in.^{2})
	(3)	Breakpoint for collective rigging	(%)
	(4)	Coefficients for rigging wing to longitudinal cyclic stick position	(deg/in.)
	(5)		(deg/in.^{2})
	(6)	Breakpoint for longitudinal cyclic rigging	(%)
	(7)	Linkage switch (0.0 for incidence)	

CARD 14C

XCWG	(8)	Coefficients for rigging right wing panel to lateral cyclic stick position	(deg/in.)
	(9)		(deg/in.^{2})
	(10)	Breakpoint for lateral stick rigging	(%)
	(11)	Coefficients for rigging right wing panel to pedal position	(deg/in.)
	(12)		(deg/in.^{2})
	(13)	Breakpoint for pedal rigging	(%)
	(14)	Coefficient for rigging wing angle to longitudinal mast tilt	(deg/deg)

2.17 STABILIZING SURFACE GROUPS (Omit all four groups if IPL(16) = IPL(17) = IPL(18) = IPL(19) = 0 or IPL(1) >9)

2.17.1 Stabilizing Surface Group No. 1 (Include only if IPL(16) ≠ 0 and IPL(1)≤9)

CARD 150 Stabilizing Surface Group No. 1 Identification Card

2.17.1.1 Basic Inputs

CARD 151

XSTB1	(1)	Stabilizing surface area	(ft^2)
	(2)	Stationline } Location of center	(in.)
	(3)	Buttline } of pressure for the	(in.)
	(4)	Waterline } stabilizing surface	(in.)
	(5)	Incidence angle	(deg)
	(6)	Effective dihedral angle (+ up)	(deg)
	(7)	Sweep angle of quarter-chord line (+ aft)	

CARD 152

XSTB1	(8)	Geometric aspect ratio of surface	
	(9)	Spanwise efficiency factor	
	(10)	Taper ratio	
	(11)	Tailboom bending coefficient	(rad/lb)
	(12)	Dynamic pressure reduction at surface due to fuselage	
	(13)	Downwash at surface due to wing	(deg)
	(14)	Control surface deflection	(deg)

CARD 153

XSTB1	(15)	Coefficients for change in lift coefficient as a function of control surface deflection	(/deg)
	(16)		(/deg^2)
	(17)	Coefficients for change in maximum lift coefficient as a function of control surface deflection	(/deg)
	(18)		(/deg^2)
	(19)	Coefficients for change in profile drag as a function of control surface deflection	(/deg)
	(20)		(/deg^2)
	(21)	Currently unused	

CARD 154

XSTB1	(22)	Coefficients for change in surface pitching moment coefficient as a function of control surface deflection	(/deg)
	(23)		(/deg^2)
	(24)	Coefficients for downwash at surface due to the fuselage	(deg)
	(25)		(deg/deg)
	(26)		(deg/deg^2)
	(27)	Coefficients for sidewash at the surface due to the fuselage	(deg/deg)
	(28)		(deg/deg^3)

CARD 155

XSTB1	(29)	Effect of Rotor 1 wake on the surface	
	(30)	Velocity at which surface starts to enter Rotor 1 wake	(kn)
	(31)	Velocity at which surface is completely in the Rotor 1 Wake	(kn)
	(32)	Effect of Rotor 2 wake on the surface	
	(33)	Velocity at which surface starts to enter Rotor 2 wake	(kn)
	(34)	Velocity at which surface is completely in the Rotor 2 wake	(kn)
	(35)	Currently unused	

2.17.1.2 Aerodynamic Inputs

CARD 156
CARD 157
CARD 158
CARD 159

YSTB1(1)→YSTB1(28) (See Section 2.16.2)

2.17.1.3 Control Linkage Inputs (Include only if IPL(16)>0)

CARD 15A

XCS1	(1)	Coefficients for rigging stabilizer angle to collective position	(deg/in.)
	(2)		(deg/in.^{2})
	(3)	Breakpoint for collective rigging	(%)
	(4)	Coefficients for rigging stabilizer angle to longitudinal cyclic stick position	(deg/in.)
	(5)		(deg/in.^{2})
	(6)	Breakpoint for longitudinal cyclic rigging	(%)
	(7)	Linkage switch (0.0 for incidence)	

CARD 15B

XCS1	(8)	Coefficients for rigging stabilizer angle to lateral cyclic position	(deg/in.)
	(9)		(deg/in.^{2})
	(10)	Breakpoint for lateral cyclic rigging	(%)
	(11)	Coefficients for rigging stabilizer angle to pedal position	(deg/in.)
	(12)		(deg/in.^{2})
	(13)	Breakpoint for pedal rigging	(%)
	(14)	Coefficient for rigging stabilizer to longitudinal mast tilt	(deg/deg)

2.17.2 Stabilizing Surface No. 2 (Include only if IPL(17) $\neq$ 0 and IPL(1) $\leq$9)

CARD 160 Stabilizing Surface No. 2 Identification Card

2.17.2.1 Basic Inputs

CARD 161
CARD 162
CARD 163 XSTB2(1)→XSTB2(35)
CARD 164
CARD 165

2.17.2.2 Aerodynamic Inputs

CARD 166
CARD 167
CARD 168 YSTB2(1)→YSTB2(28)
CARD 169

2.17.2.3 Control Linkage Inputs (Include only if IPL(17)>0 and IPL(1) $\leq$9)

CARD 16A
CARD 16B XCS2(1)→XCS2(14)

2.17.3 Stabilizing Surface No. 3 (Include only if IPL(18) $\neq$ 0 and IPL(1) $\leq$9)

CARD 170 Stabilizing Surface No. 3 Identification Card

2.17.3.1 Basic Inputs

CARD 171
CARD 172
CARD 173 XSTB3(1)→XSTB3(35)
CARD 174
CARD 175

2.17.3.2 <u>Aerodynamic Inputs</u>

CARD 176
CARD 177
CARD 178
CARD 179

YSTB3(1)→YSTB3(28)

2.17.3.3 <u>Control Linkage Inputs</u> (Include only if IPL(18)>0 and IPL(1) ≤9)

CARD 17A
CARD 17B

XCS3(1)→XCS3(14)

2.17.4 <u>Stabilizing Surface No. 4</u> (Include only if IPL(19) ≠ 0 and IPL(1) ≤9)

CARD 180 Stabilizing Surface No. 4 Identification Card

2.17.4.1 <u>Basic Inputs</u>

CARD 181
CARD 182
CARD 183
CARD 184
CARD 185

XSTB4(1)→XSTB4(35)

2.17.4.2 <u>Aerodynamic Inputs</u>

CARD 186
CARD 187
CARD 188
CARD 189

YSTB4(1)→YSTB4(28)

2.17.4.3 <u>Control Linkage Inputs</u> (Include only if IPL(19)>0 and IPL(1) ≤9)

CARD 18A
CARD 18B

XSC4(1)→XSC4(14)

2.18 JET GROUP (Omit if IPL(20) = 0 or IPL(1) >9)

CARD 190 Jet Group Identification Card

CARD 191

XJET	(1)	Number of controllable jets		
	(2)	Thrust of right, or first, jet		(lb)
	(3)	Thrust of left, or second, jet		(lb)
	(4)	Stationline	Location of right (first) jet thrust	(in.)
	(5)	Buttline		(in.)
	(6)	Waterline		(in.)
	(7)	Currently unused		

CARD 192

XJET	(8)	Yaw angle, body to right (first) jet	(deg)
	(9)	Pitch angle, body to right (first) jet	(deg)
	(10)	Currently unused	
	(11)		
	(12)		
	(13)		
	(14)		

2.19 <u>EXTERNAL STORE/AERODYNAMIC BRAKE GROUP</u> (Omit entire group if IPL(21) = 0 or IPL(1) > 9)

CARD 200 Store/Brake Group Identification Card

2.19.1 <u>Store/Brake No. 1</u> (Include only if IPL(21) $\geq$ 1)

CARD 201A

XST1	(1)	Weight of store (<0 for aerodynamic brake)	(lb)
	(2)	Stationline } Location of store/brake center of gravity	(in.)
	(3)	Buttline } Location of store/brake center of gravity	(in.)
	(4)	Waterline } Location of store/brake center of gravity	(in.)
	(5)	Distance from cg to center of pressure at α_{sc} = 0 (+ aft)	(in.)
	(6)	Distance from cp at α_{sc} = 0 to cp at α_{sc} = ±90° (+ aft)	(in.)
	(7)	Dynamic pressure loss at store	

CARD 201B

XST1	(8)	Store rolling inertia	(slug-ft^2)
	(9)	Store pitching inertia	(slug-ft^2)
	(10)	Store yawing inertia	(slug-ft^2)
	(11)	Store product of inertia	(slug-ft^2)
	(12)	Induced velocity factor from Rotor 1	
	(13)	Induced velocity factor from Rotor 2	
	(14)	Aerodynamic brake deployment	(%)

CARD 201C

XST1	(15)	L_0/q	Coefficients for store/brake lift, drag, and side force equations	(ft^2)
	(16)	L_1/q		(ft^2)
	(17)	D_0/q		(ft^2)
	(18)	D_{SIDE}/q		(ft^2)
	(19)	D_{TOP}/q		(ft^2)
	(20)	Y_0/q		(ft^2)
	(21)	Y_1/q		(ft^2)

2.19.2 Store/Brake No. 2 (Include only if $IPL(21) \geq 2$)

CARD 202A
CARD 202B
CARD 202C
XST2(1)→XST2(21); same input sequence and format as XST1(1)→XST1(21)

2.19.3 Store/Brake No. 3 (Include only if $IPL(21) \geq 3$)

CARD 203A
CARD 203B
CARD 203C
XST3(1)→XST3(21); same input sequence and format as XST1(1)→XST1(21)

2.19.4 Store/Brake No. 4 (Include only if IPL(21) = 4)

CARD 204A
CARD 204B
CARD 204C
XST4(1)→XST4(21); same input sequence and format as XST1(1)→XST1(21)

2.20 ROTOR CONTROLS GROUP

CARD 210 Controls Group Identification Card

2.20.1 Basic Controls Subgroup

CARD 211

XCON	(1)	Range of collective stick	(in.)
	(2)	Collective pitch for Rotor 1 with stick full down ($\beta_M = 0$)	(deg)
	(3)	Range of collective pitch for Rotor 1 ($\beta_M = 0$)	(deg)
	(4)	Rotor 1 collective pitch lock indicator ($\neq 0$ for locked)	
	(5)	Rotor 1 root collective pitch if XCON(4) $\neq 0$	(deg)
	(6)	Change in jet thrust with collective stick position	(lb/in.)
	(7)	Currently unused	

CARD 212

XCON	(8)	Range of longitudinal cyclic stick	(in.)
	(9)	Rotor 1 cyclic swashplate angle with stick full aft	(deg)
	(10)	Range of cyclic swashplate angle for rotor 1 due to longitudinal cyclic	(deg)
	(11)	Rotor 1 cyclic swashplate angle lock indicator ($\neq 0$ for locked)	
	(12)	Rotor 1 cyclic swashplate angle at XCON (14) azimuth if XCON(11) $\neq 0$	(deg)
	(13)	Change in jet thrust with longitudinal cyclic stick position	(lb/in.)
	(14)	Azimuth angle of maximum swashplate displacement with longitudinal cyclic stick for Rotor 1 (Default value is 0.0)	(deg)

CARD 213

XCON	(15)	Range of lateral cyclic stick	(in.)
	(16)	Rotor 1 cyclic swashplate angle with stick full left	(deg)
	(17)	Range of cyclic swashplate angle for Rotor 1 due to lateral cyclic	(deg)
	(18)	Rotor 1 cyclic swashplate angle lock indicator ($\neq 0$ for locked)	

	(19)	Rotor 1 cyclic swashplate angle at XCON(21) azimuth if XCON(18) $\neq$ 0	(deg)
	(20)	Change in jet thrust with lateral cyclic stick position	(lb/in.)
	(21)	Azimuth angle of maximum swashplate motion with lateral cyclic stick for rotor 1 (Default value is 270.0)	(deg)

CARD 214

XCON	(22)	Range of pedals	(in.)
	(23)	Rotor 2 collective pitch with pedals full right	(deg)
	(24)	Range of collective pitch for Rotor 2	(deg)
	(25)	Rotor 2 collective pitch lock indicator ($\neq$ 0 for locked)	
	(26)	Rotor 2 collective pitch if XCON(25) $\neq$ 0	(deg)
	(27)	Change in jet thrust with pedal position	(lb/in.)
	(28)	Currently unused	

2.20.2 Supplementary Controls Subgroup (Include only if IPL(22) $\neq$ 0)

CARDS 215 through 21B give the control system coupling ratios for both rotors. In the following discussion,

X_1 = Fixed-system collective intermediate control angle

X_2 = Fixed-system longitudinal cyclic intermediate control angle

X_3 = Fixed-system lateral cyclic intermediate control angle

X_4 = Fixed-system tail rotor collective intermediate control angle

$$\left.\begin{array}{l} (\theta_o)'_i = \text{Collective intermediate control angle, } i^{th} \text{ rotor} \\ (B_1)'_i = \text{Longitudinal cyclic intermediate control angle, } i^{th} \text{ rotor} \\ (A_1)'_i = \text{Lateral cyclic intermediate control angle, } i^{th} \text{ rotor} \end{array}\right\} \quad i = 1 \text{ or } 2$$

CARD 215 Collective Control Coupling

XCRT	(1)	$\partial(\theta_o)_1'/\partial X_1$	(default = 1.0)	(deg/deg)
	(2)	$\partial(\theta_o)_2'/\partial X_1$		(deg/deg)
	(3)	$\partial(B_1)_1'/\partial X_1$		(deg/deg)
	(4)	$\partial(B_1)_2'/\partial X_1$		(deg/deg)
	(5)	$\partial(A_1)_1'/\partial X_1$		(deg/deg)
	(6)	$\partial(A_1)_2'/\partial X_1$		(deg/deg)
	(7)	Currently unused		

CARD 216 Longitudinal Cyclic Control Coupling

XCRT	(8)	$\partial(\theta_o)_1'/\partial X_2$		(deg/deg)
	(9)	$\partial(\theta_o)_2'/\partial X_2$		(deg/deg)
	(10)	$\partial(B_1)_1'/\partial X_2$	(default = 1.0)	(deg/deg)
	(11)	$\partial(B_1)_2'/\partial X_2$		(deg/deg)
	(12)	$\partial(A_1)_1'/\partial X_2$		(deg/deg)
	(13)	$\partial(A_1)_2'/\partial X_2$		(deg/deg)
	(14)	Currently unused		

CARD 217 Lateral Cyclic Control Coupling

XCRT	(15)	$\partial(\theta_o)_1'/\partial X_3$		(deg/deg)
	(16)	$\partial(\theta_o)_2'/\partial X_3$		(deg/deg)
	(17)	$\partial(B_1)_1'/\partial X_3$		(deg/deg)
	(18)	$\partial(B_1)_2'/\partial X_3$		(deg/deg)
	(19)	$\partial(A_1)_1'/\partial X_3$	(default = 1.0)	(deg/deg)

(20) $\partial(A_1)_2'/\partial X_3$ (deg/deg)

(21) Currently unused

CARD 218 Pedal Control Coupling

XCRT (22) $\partial(\theta_o)_1'/\partial X_4$ (deg/deg)

(23) $\partial(\theta_o)_2'/\partial X_4$ (default = 1.0) (deg/deg)

(24) $\partial(B_1)_1'/\partial X_4$ (deg/deg)

(25) $\partial(B_1)_2'/\partial X_4$ (deg/deg)

(26) $\partial(A_1)_1'/\partial X_4$ (deg/deg)

(27) $\partial(A_1)_2'/\partial X_4$ (deg/deg)

(28) Currently unused

CARD 219 Control Linkage to Longitudinal Mast Tilt Angle

XCRT (29) Switch to change rotor control linkages with longitudinal mast tilt (0.0 = no change)

(30) } Coefficients for changing XCON(2) as a function of longitudinal mast tilt (deg/deg)

(31) (deg/deg^2)

(32) Range of collective pitch for Rotor 1 at longitudinal mast tilt = 90° (default = 100.0) (deg)

(33) Coefficient for modifying XCRT(5) and XCRT(6) as a function of longitudinal mast tilt (deg/deg)

(34) } Coefficients for modifying XCRT(10) as a function of longitudinal mast tilt (deg/deg)

(35) (deg)

CARD 21A Nonlinear Rigging

XCRT (36) Coefficient for nonlinear rigging of collective (deg/in.^2)

(37) } Coefficients for nonlinear rigging of longitudinal cyclic (deg/in.^2)

(38) (deg/in.^3)

(39) } Coefficients for nonlinear rigging of lateral cyclic (deg/in.^2)

(40) (deg/in.^3)

	(41)	Coefficients for nonlinear	(deg/in.^{2})
	(42)	rigging of pedals	(deg/in.^{3})

CARD 21B Cyclic Actuator Phasing

XCRT	(43)	Azimuth for maximum swashplate motion with longitudinal cyclic stick for Rotor 2 (default = 0.0)	(deg)
	(44)	Azimuth for maximum swashplate motion with lateral cyclic stick for Rotor 2 (default = 270.0)	(deg)
	(45)	Currently unused	
	(46)		
	(47)		
	(48)		
	(49)		

2.21 ITERATION LOGIC GROUP

CARD 220 Iteration Logic Group Identification Card

CARD 221

XIT	(1)	Iteration limit for TRIM		
	(2)	$\Delta\psi$ of rotor(s) for time-variant trim	(deg)	
	(3)	Limiter for change in average rotor-induced velocity	(ft/s)	
	(4)	Partial derivative increment for STAB		
	(5)	Number of rotor revolutions worth of data to be passed to GDAP80 for postprocessing (default = 1)		*
	(6)	Number of rotor revolutions in TVT and FTVT (0 reset to 3.0 in FTVT, to 5.0 in TVT)		
	(7)	Damper to suppress blade torsional "bounce" (0 reset to 0.3)		

2.21.1 Variable Damper Inputs +

CARD 222

XIT	(8)	Starting value of Rotor 1 longitudinal flapping correction limit	(deg)
	(9)	Starting value of Rotor 1 lateral flapping correction limit	(deg)
	(10)	Starting value of Rotor 2 longitudinal flapping correction limit	(deg)
	(11)	Starting value of Rotor 2 lateral flapping correction limit	(deg)
	(12)	Starting value of collective correction limit	(deg)
	(13)	Starting value of longitudinal cyclic correction limit	(deg)
	(14)	Currently unused	

CARD 223 +

XIT	(15)	Starting value of lateral cyclic correction limit	(deg)
	(16)	Starting value of pedal correction limit	(deg)
	(17)	Starting value of fuselage Euler yaw angle correction limit	(deg)
	(18)	Starting value of fuselage Euler pitch angle correction limit	(deg)
	(19)	Starting value of fuselage Euler roll angle correction limit	(deg)
	(20)	Starting value of airframe rate of climb correction limit	(ft/s)
	(21)	Currently unused	

+ New Card

CARD 224 +

XIT	(22)	Minimum value of Rotor 1 longitudinal flapping correction limit	(deg)
	(23)	Minimum value of Rotor 1 lateral flapping correction limit	(deg)
	(24)	Minimum value of Rotor 2 longitudinal flapping correction limit	(deg)
	(25)	Minimum value of Rotor 2 lateral flapping correction limit	(deg)
	(26)	Minimum value of collective correction limit	(deg)
	(27)	Minimum value of longitudinal cyclic correction limit	(deg)
	(28)	Currently unused	

CARD 225 +

XIT	(29)	Minimum value of lateral cyclic correction limit	(deg)
	(30)	Minimum value of pedal correction limit	(deg)
	(31)	Minimum value of fuselage Euler yaw angle correction limit	(deg)
	(32)	Minimum value of fuselage Euler pitch angle correction limit	(deg)
	(33)	Minimum value of fuselage Euler roll correction limit	(deg)
	(34)	Minimum value of airframe rate of climb correction limit	(ft/s)
	(35)	Currently unused	

CARD 226 +

XIT	(36)	Rotor 1 longitudinal flapping moment imbalance at which the variable damper is activated	(ft-lb)
	(37)	Rotor 1 lateral flapping moment imbalance at which the variable damper is activated	(ft-lb)
	(38)	Rotor 2 longitudinal flapping moment imbalance at which the variable damper is activated	(ft-lb)
	(39)	Rotor 2 lateral flapping moment imbalance at which the variable damper is activated	(ft-lb)
	(40) (41) (42)	$\left.\right\}$ Currently unused	

+ New Card

CARD 227 +

XIT	(43)	Aircraft longitudinal force imbalance at which the variable damper is activated	(lb)
	(44)	Aircraft lateral force imbalance at which the variable damper is activated	(lb)
	(45)	Aircraft vertical force imbalance at which the variable damper is activated	(lb)
	(46)	Aircraft yawing moment imbalance at which the variable damper is activated	(ft-lb)
	(47)	Aircraft pitching moment imbalance at which the variable damper is activated	(ft-lb)
	(48)	Aircraft rolling moment imbalance at which the variable damper is activated	(ft-lb)
	(49)	Aircraft horsepower imbalance at which the variable damper is activated	(HP)

2.21.2 Allowable Error Inputs

CARD 228 +

XIT	(50)	Allowable error in Rotor 1 longitudinal flapping moment balance	(ft-lb)
	(51)	Allowable error in Rotor 1 lateral flapping moment balance	(ft-lb)
	(52)	Allowable error in Rotor 2 longitudinal flapping moment balance	(ft-lb)
	(53)	Allowable error in Rotor 2 lateral flapping moment balance	(ft-lb)
	(54) (55) (56)	Currently unused	

CARD 229 +

XIT	(57)	Allowable error in aircraft longitudinal force balance	(lb)
	(58)	Allowable error in aircraft lateral force balance	(lb)
	(59)	Allowable error in aircraft vertical force balance	(lb)
	(60)	Allowable error in aircraft Euler yawing moment balance	(ft-lb)
	(61)	Allowable error in aircraft Euler pitching moment balance	(ft-lb)
	(62)	Allowable error in aircraft Euler rolling moment balance	(ft-lb)
	(63)	Allowable error in horsepower balance	(HP)

+ New Card

2.21.3 Desired Trim Imbalance Inputs

CARD 22A +

XIT (64), (65) — Currently unused

(66) Desired aircraft vertical acceleration (ft/s^2)

(67), (68), (69) — Currently unused

(70) Desired engine horsepower (HP)

CARD 22B +

XIT (71) Multiplier on STAB control partial derivative matrix increment

(72), (73), (74), (75), (76), (77) — Currently unused

+ New Card

2.22 FLIGHT CONSTANTS GROUP

CARD 230 Flight Constants Group Identification Card

CARD 231

XFC	(1)	Forward velocity (ground reference)	(kn)
	(2)	Lateral velocity (ground reference)	(kn)
	(3)	Rate of climb (ground reference)	(ft/sec)
	(4)	Geometric altitude (controls ground effect)	(ft)
	(5)	Euler angle yaw (heading angle)	(deg)
	(6)	Euler angle pitch	(deg)
	(7)	Euler angle roll	(deg)

CARD 232

XFC	(8)	Collective stick position	(%)
	(9)	Longitudinal cyclic stick position	(%)
	(10)	Lateral cyclic stick position	(%)
	(11)	Pedal position	(%)
	(12) (13) (14)	Currently unused	*

CARD 233

XFC	(15)	Rotor 1 longitudinal flapping angle	(deg)
	(16)	Rotor 1 lateral flapping angle	(deg)
	(17)	Rotor 2 longitudinal flapping angle	(deg)
	(18)	Rotor 2 lateral flapping angle	(deg)
	(19)	Rotor 1 thrust	(lb)
	(20)	Rotor 2 thrust	(lb)
	(21)	Currently unused	

CARD 234

XFC	(22) (23)	Currently unused	
	(24)	Maximum engine horsepower available	(hp)
	(25)	Engine RPM	(rpm)
	(26)	Atmospheric logic switch (0.0 = Std Day; >0, but <100.0, XFC(28) is °F, <0, XFC(28) is °C; ≥100.0, XFC(27) is the density of ratio and XFC(28) is the speed of sound)	
	(27)	Pressure altitude or density ratio	(ft)
	(28)	Ambient temperature or speed of sound	(°C, °F, or ft/sec)

NOTE: END OF TRIM OR TRIM-STAB DECK; NPART = 1 AND NPART = 7 DECKS MAY ONLY BE FOLLOWED BY PARAMETER-SWEEP CARDS (NPART = 10) AND GDAP80 POSTPROCESSING CARDS.

2.23 BOBWEIGHT GROUP (Include only if NPART = 2 or 4 and IPL(23) $\neq$ 0)

CARD 240 Bobweight Group Identification Card

CARD 241

XBW	(1)	Effectivity coefficient	(deg/in.)
	(2)	Spring constant	(lb/in.)
	(3)	Damping coefficient	(lb-sec/in.)
	(4)	Weight of bobweight	(lb)
	(5)	Currently unused	
	(6)	Currently unused	
	(7)	Preload	(g)

2.24 WEAPONS GROUP (Include only if NPART = 2 or 4 and IPL(23) $\neq$ 0)

CARD 250 Weapons Group Identification Card

CARD 251

XGN	(1)	Stationline – Location of weapon	(in.)
	(2)	Buttline – Location of weapon	(in.)
	(3)	Waterline – Location of weapon	(in.)
	(4)	Azimuth (+ right)	(deg)
	(5)	Elevation (+ up)	(deg)
	(6)	Currently unused	
	(7)	Currently unused	

Note: Use the weapons group in conjunction with a J = 16 card, Section 4.29.2.10.

2.25 SCAS GROUP (Include only if NPART = 2 or 4 and IPL(23) $\neq$ 0)

CARD 260 SCAS Group Identification Card

CARD 261

XSCAS	(1)	K_H, Roll response feedback gain		$\frac{\text{(in. of stick)}}{\text{(deg/sec)}}$
	(2)	τ_1	Roll channel time constants	(sec)
	(3)	τ_2		(sec)
	(4)	τ_3		(sec)
	(5)	τ_4		(sec)
	(6)	τ_5		(sec)
	(7)	K_G, Roll pilot feed-forward gain		$\frac{\text{(in. of stick)}}{\text{(in. of stick/sec)}}$

CARD 262

XSCAS	(8)	K_H, Pitch response feedback gain		$\frac{\text{(in. of stick)}}{\text{(deg/sec)}}$
	(9)	τ_1	Pitch channel time constants	(sec)
	(10)	τ_2		(sec)
	(11)	τ_3		(sec)
	(12)	τ_4		(sec)
	(13)	τ_5		(sec)
	(14)	K_G, Pitch pilot feed-forward gain		$\frac{\text{(in. of stick)}}{\text{(in. of stick/sec)}}$

CARD 263

XSCAS	(15)	K_H, Yaw response feedback gain		$\frac{\text{(in. of pedal)}}{\text{(deg/sec)}}$
	(16)	τ_1	Yaw channel time constants	(sec)
	(17)	τ_2		(sec)
	(18)	τ_3		(sec)
	(19)	τ_4		(sec)
	(20)	τ_5		(sec)
	(21)	K_G, Yaw pilot feed-forward gain		$\frac{\text{(in. of pedal)}}{\text{(in. of pedal/sec)}}$

CARD 264

XSCAS	(22)	Maximum authority in Roll	(%)
	(23)	Maximum authority in Pitch	(%)
	(24)	Maximum authority in Yaw	(%)
	(25)	Dead band for d/dt (Roll Moment)	(ft-lb/sec)
	(26)	Dead band for d/dt (Pitch Moment)	(ft-lb/sec)
	(27)	Dead band for d/dt (Yaw Moment)	(ft-lb/sec)
	(28)	Currently unused	

2.26 STABILITY ANALYSIS TIMES GROUP (Include only if NPART = 2, 4, or 5 and IPL(23) ≠ 0)

CARD 270 Stability Analysis Times Group Identification Card

CARD 271

TSTAB	(1)	Time or azimuth angle for first analysis	(sec or deg)
	(2)	Time or azimuth angle for second analysis	(sec or deg)
	(3)	Time or azimuth angle for third analysis	(sec or deg)
	(4)	Time or azimuth angle for fourth analysis	(sec or deg)
	(5)	Time or azimuth angle for fifth analysis	(sec or deg)
	(6)	Time or azimuth angle for sixth analysis	(sec or deg)
	(7)	Time or azimuth angle for seventh analysis	(sec or deg)

CARD 272

TSTAB	(8)	Time or azimuth angle for eighth analysis	(sec or deg)
	(9)	Time or azimuth angle for ninth analysis	(sec or deg)
	(10)	Time or azimuth angle for tenth analysis	(sec or deg)
	(11)	Time or azimuth angle for eleventh analysis	(sec or deg)
	(12)	Time or azimuth angle for twelfth analysis	(sec or deg)
	(13)	Time or azimuth angle for thirteenth analysis	(sec or deg)
	(14)	Time or azimuth angle for fourteenth analysis	(sec or deg)

NOTE: If no rotorcraft stability analyses are to be performed, TSTAB(1) must refer to a time or rotor azimuth angle after the end of the maneuver. A value of 9999. (seconds) is suggested as the input for such a case.

2.27 BLADE ELEMENT DATA PRINTOUT GROUP (Include only if NPART = 2, 4, or 5 and IPL(23) $\neq$ 0)

CARD 280 Blade Element Data Printout Group Identification Card

CARD 281

TAIR	(1)	Time or azimuth angle for first printout	(sec or deg)
	(2)	Time or azimuth angle for second printout	(sec or deg)
	(3)	Time or azimuth angle for third printout	(sec or deg)
	(4)	Time or azimuth angle for fourth printout	(sec or deg)
	(5)	Time or azimuth angle for fifth printout	(sec or deg)
	(6)	Time or azimuth angle for sixth printout	(sec or deg)
	(7)	Time or azimuth angle for seventh printout	(sec or deg)

CARD 282

TAIR	(8)	Time or azimuth angle for eighth printout	(sec or deg)
	(9)	Time or azimuth angle for ninth printout	(sec or deg)
	(10)	Time or azimuth angle for tenth printout	(sec or deg)
	(11)	Time or azimuth angle for eleventh printout	(sec or deg)
	(12)	Time or azimuth angle for twelfth printout	(sec or deg)
	(13)	Time or azimuth angle for thirteenth printout	(sec or deg)
	(14)	Time or azimuth angle for fourteenth printout	(sec or deg)

NOTE: If no printouts are to be made, TAIR(1) must refer to a time or rotor azimuth angle after the end of the maneuver. A value of 9999. (seconds) is suggested as the input for such a case.

2.28 <u>MANEUVER TIME CARD</u> (Include only if NPART = 2, 4, or 5)

CARD 291 (6F10.0)

TCI	(1)	Start time of maneuver	(sec)
	(2)	First time or azimuth increment	(sec or deg)
	(3)	Time to stop using first increment	(sec)
	(4)	Second time or azimuth increment	(sec or deg)
	(5)	Time to stop using second increment and return to first increment	(sec)
	(6)	Time to stop the maneuver	(sec)
	(7)	Currently unused	

2.29 <u>MANEUVER SPECIFICATION CARDS</u> (These cards may be included only if NPART = 2, 4, or 5)

CARD 301 (A1, I4, 5X, 6F10.0)

Col 1	THISJC (blank except for last card in group)
Col 2 - 5	J, variation selector
Col 11 - 20 Col 21 - 30 Col 31 - 40 Col 41 - 50 Col 51 - 60 Col 61 - 70	Inputs which define the variations for each value of J in 6F10.0 format

CARD 302 Same format as CARD 301

CARD 303 Same format as CARD 301

CARD 304 Same format as CARD 301

etc.

Note: A maximum of 20 maneuver specification cards is permitted.

3. INPUT FORMAT FOR GDAP80

Eight postprocessing operations can be performed on data created by AGAP80, as outlined in Figure 9. Separate postprocessing data blocks are created by every quasi-static trim for which IPL(79) is not equal to zero, by every time-variant trim and by a maneuver.

The FORTRAN input format is given in parentheses after the CARD number.

3.1 INDEXING POSTPROCESSING DATA BLOCKS

CARD 11 (I2)

Col	1-2	NPART (Must equal 14 to move to the next Postprocessing Data Block)

3.2 PLOTTING OF TIME-HISTORY DATA

CARD 21 (I2, 1X, I3)

Col	2	NPART (Must equal 3 for plotting)
Col	4 - 6	NPRINT Print Control

CARDs 22A, 22B (A1, I4, 1X, I4, 1X, I4, 4X, I1, 10X, 3F10.0)
(One for each set of plots desired - 10 maximum)

Col	1	KEYS (blank except for the last 22-type card)
Col	2 - 5	KV1, Code of variable 1
Col	7 - 10	KV2, Code of variable 2
Col	12 - 15	KV3, Code of variable 3
Col	20	KEY (1 = plot on Printer only)
Col	31 - 40	SC1, Minimum scale for KV1
Col	41 - 50	SC2, Minimum scale for KV2
Col	51 - 60	SC3, Minimum scale for KV3

See Section 9 for the code numbers to be used for KV1, KV2, and KV3.

3.3 STABILITY ANALYSIS USING MOVING BLOCK FAST FOURIER TRANSFORM

CARD 31 (I2)

Col.	2	NPART (must equal 6 for moving block FFT method)

CARD 32A, 32B,... (A1, 4X, 2I5, 5X, 3F10.0)

Col.	1	CONT (blank except for last card in group)	
	6 - 10	Code number of variable to be analyzed (see Section 9; data must be available)	
	11 - 15	N, number of cycles of data, at frequency f, to be analyzed	
	21 - 30	t_o, start time	(sec)
	31 - 40	f, central frequency for moving block FFT	(Hz)
	41 - 50	Δf, half-bandwidth for analysis	(Hz)

NOTE: The last CARD 32 must have some character in Column 1, and all other CARD 32's must have a blank in Column 1. Also, the variable to be analyzed has to have been computed during the trim or maneuver; i.e., if the user wishes to analyze the stability of Rotor 1 bending moment data, Rotor 1 must have been elastic and time-variant during the trim or maneuver which generated the Postprocessing Data Block.

3.4 STORING TIME-HISTORY DATA ON TAPE (This card may be included only for the Postprocessing Data Block resulting from a maneuver.)

CARD 41 (I2, 8X, I5)

Col.	2	NPART (must be equal 8 for tape file operations)
	11 - 15	NVARA (must be blank or all zeros to store data)

NOTE: Time-history data which has been stored on tape can be retrieved with an AGAP80 deck with NPART = 8.

3.5 HARMONIC ANALYSIS OF TIME-HISTORY DATA

CARD 51 (I2, 8X, I5, 5X, 2F5.0, 5X, I5, 5X, F5.0)

Col. 2	NPART (must equal 9 for harmonic analysis)	
11 - 15	NVARA, number of variables to be frequency analyzed	
21 - 25	AL(1), start time for interval to be analyzed	(sec)
26 - 30	AH(1), stop time for interval to be analyzed	(sec)
31 - 35	NVARB, print control for amplitude function (0 = print only)	
41 - 45	AL(2), base frequency for analysis (0.0 = M/R 1/rev)	(cps)

CARDS 52 (14I5)

Code numbers of variables to be analyzed (see Section 9 for code numbers).

The user can input several sets of 51-52 cards if harmonic analysis of more than 14 variables is desired.

3.6 VECTOR ANALYSIS OF TIME-HISTORY DATA

CARD 61 (I2, 8X, I5, 5X, F5.0, 5X, I5, 5X, F5.0, 5X, I5)

Col 1 - 2	NPART (must equal 11 for curve fitting)	
11 - 15	NVARA, total number of curves to be fit in Step 1	
21 - 25	AL(1), baseline frequency for Step 1	(cps)
31 - 35	NVARB, total number of reference curves for Step 2	
41 - 45	AL(2), total number of curve fits in Step 3	
51 - 55	NVARC, number of time points to be skipped before step 1 curve fit begins	

CARD 62A, 62B, etc. (14I5)

Code number of curves to be fit in Step 1

CARD 63A, 63B, etc. (NVARB sets of these cards, 14I5 for each card)

Col 1 - 5	NX, quantity of variables to be compared to reference variables
6 - 10	Code number of reference variable
11 - 15 16 - 20 21 - 25 . . .	NX code numbers of variables to be compared to reference variable

CARDS 64A, 64B, etc. (AL(2) cards of this type, 3I5)

Col 1 - 5	Code number for variable C
6 - 10	Code number for variable D
11 - 15	Code number for variable E

See Section 9 for the code numbers of the variables.

3.7 TABULATIONS AND CONTOUR PLOTS OF SELECTED VARIABLES

CARD 71 (I2, 2I4, I5, 5X, F5.0)

Col 1-2	NPART (must equal 12 for tabulation and contour plot operation)
3-6	NPRINT, Switch for tabulations (0 = off, 1 = on)
7-10	NSCALE, Switch for contour plots (0 = off, 1 = on)
11-15	NVARA, Rotor identification number
21-25	AL(1), Start time for tabulation and/or plots (sec)

CARDS 72A, 72B, etc. (A1, I4, 13I5)

Code numbers of variables to be presented (see Section 5.7). The first card column of the 72-type cards must be blank except for the last card in the list. The last card in the list must have some character (a slash is recommended) in Card Column 1.

3.8 STABILITY ANALYSIS USING PRONY'S METHOD

CARD 81 (I2, I4)

Col	1 - 2	NPART (must equal 13 for Prony's method)
	3 - 6	NPRINT, plot control

CARD 82A, 82B, ... (A1, I4, 3I5, 3F10.0)

Col	1	CONT (blank except for the last card in the group)
	2 - 5	NRPM = 0 or 1: the output is based on the rpm of Rotor 1 = 2: the output is based on the rpm of Rotor 2
	6 - 10	MVAR, the code number of the variable to be analyzed (see Section 9)
	11 - 15	M, the number of terms to be used in the curve fit (maximum of 40)
	16 - 20	KSKIP, the number of points to be skipped in the time histories
	21 - 30	TSTART, start time (sec)
	31 - 40	TSTOP, stop time (sec)
	41 - 50	SC1, minimum plot scale factor

NOTE: The last CARD 82 must have some character in Column 1, and all other CARD 82's must have a blank in Column 1. Also, the variable to be analyzed has to have been computed during the trim or maneuver; i.e., if the user wishes to examine the stability of Rotor 1 bending moment data, Rotor 1 must have been elastic and time-variant during the trim or maneuver.

3.9 CREATION OF A DATA TRANSFER FILE (DTF)

CARD 91 (I2, 2I4)

Col	1 - 2	NPART (must equal 15 for Data Transfer File Creation)
	3 - 6	NPRINT, number of cards of user-supplied DATAMAP File Creation Program instructions.
	7 - 10	NSCALE, number of Generated Data Group names
	11 - 15	Format indicator

CARDs 92A, 92B (15A4) File Creation Program Instructions

There are NPRINT cards of this type, containing user-supplied File Creation Program (FCP) instructions. Several instructions may appear on each card, in free format. Column 1 of each card may be non-blank, as Program GDAP80 reads exactly NPRINT cards in this category.

CARDs 93A, 93B (A1,A4,13(1X,A4)) Group Data Selection

If NSCALE is zero or blank, no 93-type cards should be included in the deck.

The first card column of all but the last of these cards must be blank. The first card column of the last 93-type card must also be blank if any 94-type cards follow the 93-type cards. If no 94-type cards are to be included in the NPART=15 card set, then the last 93-type card must have some alphanumeric character in the first card column. A slash is recommended.

The four-character names of the Generated Data Groups to be included in the Data Transfer File for this counter are input on these cards. The names must be right-justified in five-column fields, and there must be no blank fields in the first NSCALE fields.

CARDs 94A, 94B, etc., (A1,I4,13I5) Individual Data Selection

The first card column of all but the last of these cards must be blank. The last card must have some alphanumeric character in the first card column.

Time-histories for individual data items are included in the DTF by specifying the appropriate data item code number on these cards. The item codes may be found in Table 28 of Section 9. The item codes must be right-justified in five-column fields, 14 to a card.

Item codes specified individually by the user should not duplicate those specified through the invocation of a Generated Data Group name. Also, the user should not specify the rotor azimuth item codes (320 and 333) because they are automatically included in the Data Transfer File.

4. USER'S GUIDE TO INPUT FORMAT FOR AGAP80

This section of the report presents a discussion of the inputs defined in Section 2. It is primarily intended for the inexperienced user of the program and for reference purposes. To simplify cross-reference between the two sections, the numbers of the subsections of this section correspond to those in Section 2.; e.g., the inputs for the Iteration Logic Group given in Section 2.21 are discussed in Section 4.21.

The units for each dimensional input are given at the right side of the page throughout Section 2. Whenever possible, inputs that have units that normally cancel are notated without cancelling the units for clarification, such as (in.-lb-sec^2/in.).

Most inputs are read into arrays. The first character in each array name and in most individual variables is a code for the general classification of the array or variable, as follows:

- X In general, inputs which can be physically measured, analytically determined, or defined, and which relate directly to the rotorcraft configuration.
- Y Inputs related to aerodynamic characteristics of the aircraft component.
- I Integer inputs which control program logic.
- T Inputs related to time points in a maneuver.

4.1 GENERAL

4.1.1 Composition of A Data Deck and Card Format

An input data deck must be set up to perform one and only one of the following primary program operations:

(1) Determination of trimmed flight condition only.
(2) Trim followed by a rotorcraft stability analysis.
(3) Sweeps of trim conditions with or without a rotorcraft stability analysis.
(4) Trim followed by a maneuver without a rotorcraft stability analysis.
(5) Trim followed by a maneuver with a rotorcraft stability analysis.
(6) Trim followed by a maneuver in which maneuver time-point data are stored for a subsequent restart of the maneuver.

(7) Maneuver restart.
(8) Retrieval of maneuver data stored on tape.

These eight operations are shown in Figures 1 through 8 respectively. The implication of the statement "one and only one" above is that data decks that perform different primary operations must not be stacked; they must be submitted as separate runs. For example, suppose the user wants data on a particular configuration for: (1) a trim and a rotorcraft stability analysis at 100 knots, and (2) a maneuver which starts from a 120-knot trim condition. The two cases must be submitted separately. However, in the first case the user may set the deck up as a parameter sweep so that the 100-knot trim with rotorcraft stability analysis is followed by a trim at 120 knots. The data from the 120-knot trim can then be used as inputs to the second case to shorten the time required for the 120-knot trim prior to the maneuver. It is not possible to follow a parameter sweep case with a maneuver.

The AGAP80 input deck is subdivided into input groups where each group contains a set of related data (e.g., rotor, fuselage, and wing parameters; program logic specification; and data tables). The complete list of all possible input groups in the order in which they must be input is presented in Table 1.

In most cases, the user will not need to use every group to define the configuration that is to be simulated. Hence, as a user convenience, the first two data cards of the first group of input data (the Program Logic Group) contain over 20 switches that specify the groups and/or arrays that must or must not be included in the data deck. This feature eliminates the necessity of including sets of blank cards or dummy inputs for groups which are not needed. During the reading of the data deck and initialization of input data, many checks are performed to assure that the specifications of the Program Logic Group and the groups that follow are compatible and complete. Obviously, the checking procedure cannot correct or diagnose every possible input error, and the user must exercise the normal amount of care in following the instructions of this input guide.

In Section 2, each card of input data is identified by a sequence number. Within an individual group the numbers are consecutive. However, the capability of adding and deleting

entire groups from the deck precludes consecutive numbering between groups. Considering the large number of cards which can be included in a deck, it is strongly recommended that all cards be numbered according to the sequence numbers given in Section 2 and used in this section. Doing so will greatly simplify locating specific inputs and reconstructing a dropped or shuffled deck.

4.1.2 Group Identification Cards and the Analytical Data Base

All of the AGAP80 input groups are headed by a Group Identification (ID) Card. The use of this card is discussed in this section and is not repeated for each group with an ID card.

The primary purpose of the ID cards is to provide a means for using the Analytical Data Base (ADB) Option discussed below. Hence, groups which cannot be called from the ADB (i.e., deck identification cards and the maneuver time specification and data analysis cards) do not have ID cards. A secondary purpose of the ID cards is to provide a convenient means of identifying the start of a new group and including comments pertaining to individual groups in the deck.

The Analytical Data Base Option (and its MODEL Option subset) is included in the master version of AGAP80. The local programmer should be consulted to see if the option is available with the installed version of the program; if it is not (or the option is not to be used), the first eight columns of each ID card must be blank, and the following discussion may be bypassed.

The data stored on the Analytical Data Base consist of two types:

(1) The input data for a specific input group of a particular rotorcraft (Group Data Sets)
(2) The set of input groups which constitute all the groups needed for a particular rotorcraft (Model Data Sets)

The number of cards in a Group Data Set is equal to the maximum number of cards which may be required for the appropriate input group. The number of cards in a Model Data Set is 49 (51 with comment cards) where each card corresponds to a particular input group and one element of the MODEL array in the program. Setup and maintenance of the ADB are generally assigned to a programmer. Consequently, the technical details relating to the establishment of an ADB are not presented in this volume.

The Analytical Data Base does not contain any inputs for GDAP80.

Each Group and Model Data Set on the ADB is assigned a unique eight-character alphanumeric name. These names are then used to identify the data sets and as the data on the cards in a Model Data Set. The characters used in the name of a Group Data Set are arbitrary, but the first four characters in the name of any Model Data Set must be MODL.

Once data are stored on the Data Base, IDEN on the ID cards may be used to call a data set from the ADB. When the first eight columns of an ID card are blank, it is assumed that the Data Base is not to be used, and all cards for the appropriate input groups must follow the ID card. If these columns are not blank, they are assumed to contain the name of a data set which is on the ADB, and the program searches the ADB for the data set with the corresponding name. If the name is not found, a message to that effect is printed and execution of the program is terminated.

When the name is a group name (i.e., does not start with the four characters MODL) and is found, the corresponding data set is used as the input data for that group. In this case, all remaining cards for that group must be omitted from the card deck. The reading of each group ID card is completely independent of the reading of any other ID card. Hence, a card deck may contain any combination of groups called from the ADB and groups input on cards which suits the user's purpose.

When a Model Data Set is to be used, the Analytical Data Base name must be input on CARD 10 (the Program Logic Group ID Card). If the first four columns on CARD 10 contain the characters MODL, the program will search the ADB for the Model Data Set with the corresponding eight-character name. If the name is not found, execution terminates. When the data set is found, the program then uses the ADB groups whose names are in the Model Data Set as the source of input data for all input groups. In this case, the cards for all groups included in the data set must be omitted from the card deck.

4.1.3 Procedures for Changing Input Data

Frequently, it is desirable or necessary to change the values of a few individual inputs in groups called from the ADB and/or to replace certain groups in a Model Data Set with other groups. Also, it is necessary to have a means of changing inputs when performing parameter sweeps. The FORTRAN NAMELIST feature, using &CHANGE and &GROUPS cards, is provided to accomplish these tasks.

The cards that are used to exercise these features must conform to a special format:

(1) Column 1 of all cards must be blank.

(2) Columns 2 through 8 of the first card must contain the seven characters &CHANGE or &GROUPS, as appropriate.

(3) Column 9 of the first card must be blank.

(4) Change items (defined below) can start in or after Column 10 of the first card and in or after Column 2 of any subsequent card(s); items must be separated by commas, and not extend past Column 70. Note that the IBM NAMELIST option will read all 80 columns on a card, including sequence numbers.

(5) After the last character of the last change item there must be a comma or a blank column followed by the four characters &END. The &END must not extend past column 70.

4.1.3.1 Change Items for &CHANGE Cards

The change items for &CHANGE cards must be in one of two forms:

Symbolic Name = Constant

or

Array Name = Set of Constants (separated by commas)

The set of characters to be used for Symbolic Name is the array name and element number of the variable to be changed. Only those arrays and elements listed in Table 2 can be changed. Constant is the new value of the variable indicated. The set of characters for Array Name must be one of the array names included in Table 2. The Set of Constants is then the new values for the array. The number of constants in the set must be less than or equal to the dimension of the array as given in Table 2. In the Set of Constants the successive occurrences of the same constant can be represented by the form

k*constant

where k is a nonzero integer specifying the number of times the constant is to occur.

Blank columns are permitted before and after the equal sign in a change item and after the comma which separates change items. However, blank columns are not permitted within a name or a constant, and trailing blanks after an integer or exponent are treated as zeros.

Although a set of change items can be continued onto as many cards as needed, a single change item must not be split between cards and only the data on the first card of a continued set will be printed in the output data.

An example of the data for the &CHANGE operation is as follows:

```
                  Column 1
                      ↓
First Card:           b&CHANGEbXFS(1)=9500.0, XMR(44)=5.0,

Second Card:          bIPL(48)=0, TAIR=7*9999., &END
```

where b indicates a mandatory blank column; other blank columns shown are optional. This example will change gross weight to 9500 pounds, the Rotor 1 longitudinal mast tilt angle to 5 degrees, the rotor aerodynamic option to steady state only, and the first seven times for blade element data printout to 9999.0 seconds.

It is not necessary that change items be in any specified order. For example, the first change item can be for XFS(10), the second for XFS(8), and the third for XFS(1), the fourth for IPL(45), etc.

As noted above, only the first card of a set of &CHANGE cards like the example is printed in the output data. To get data from both cards included in the printout, use the following form:

```
                  Column 1
                      ↓
First Card:           b&CHANGEbXFS(1)=9500., XMR(44)=5.0, &END
                      ↓
Second Card:          b&CHANGEbIPL(48)=0, TAIR=7*9999., &END
```

Like the continued card set, this form can also consist of as many cards as needed; each will be included in the printout. (NOTE: only one &CHANGE card can follow an NPART=10 card.)

An idiosyncrasy of the FORTRAN NAMELIST feature is that a sequence number in column 73 through 80 of the first card in the original example would have been read as a variable name and caused an abnormal end of job. The second form of the example, in which each card has an &END, is one way to avoid this problem. An alternative would be to avoid sequence numbers on NAMELIST cards.

4.1.3.2 Change Items for &GROUPS Cards

The change items for &GROUPS cards must be in the following form:

MODEL(xx) = 'yyyyyyyy'

The blanks on either side of the equal sign are optional. MODEL is an array in the program (dimensioned to 49); the data for the elements of this array are the Model Data Sets stored on the ADB. The symbol xx must be the one- or two-digit element number of the group to be replaced (element numbers are defined in Table 1). The symbol yyyyyyyy is the eight-character name for the ADB group which is to replace the xx element. The single quote mark at either end of the Data Base name is mandatory.

An example of the data for the &GROUPS operation is as follows:

Column 1

```
b&GROUPSbMODEL(3)='CLCD0015', &END
```

This example will cause the second airfoil data table (MODEL array element number 3) to be replaced by the CLCD0015 data table.

To replace the entire xx element of a Model Data Set with a group which is not on the ADB, leave the eight columns for the MODEL element name (yyyyyyyy) completely blank. The required location in the deck for the externally supplied group(s) is discussed in the next subsection. The rules for the form of the &GROUPS change items are the same as for the &CHANGE change items.

4.1.3.3 Location of &CHANGE and &GROUPS Cards

When &CHANGE cards are used to update individual Data Base groups, the set of cards is to be placed immediately after the Group ID card of the group being changed. When used to make changes for parameter sweeps, the cards are placed immediately after the sweep card (the second CARD 01, or NPART card, with NPART=10) which follows the last card of the Flight Constants Group (CARD 234).

The location of the &GROUPS and &CHANGE cards in a deck which uses the MODEL Option is shown in the sample deck listed in Figure 18. In the example, the first airfoil data table (element 2) is to be replaced by the CLCDVS12 table from the

ADB while the Flight Constants Group (element 44) is to be replaced with data included in the deck. The &CHANGE card shown updates the fuselage equivalent flat plate drag area.

The general rules for including the cards for groups with blank names in the &GROUPS card are:

(1) the order of input of the change items on the &GROUPS card is optional, but the added groups must be included in the deck in the same sequence as their MODEL array element number, and

(2) the ID card of the included group must not be included in the deck.

Although it is possible in some cases to change the values on the first two cards of the Program Logic Group (IPL(1-28), which specify the groups that must be in the deck), the procedure is complex, not recommended, and not discussed in this report. If a Model Data Set needs to be changed that drastically, the user should be entering data by individual groups, not MODEL Option.

4.2 IDENTIFICATION AND PROGRAM FLOW CONTROL GROUP

CARD 00 Message Card

The alphanumeric inputs on this card are printed six times on the first page of printed output. The comments are intended to describe the disposition of the input card deck and printed output.

CARD 01 NPART Card

This card includes the primary program control variable, NPART, and is referred to as the NPART card. Permissible values of NPART on this card are 1, 2, 4, 5, 7, and 8. The value of NPART specifies the type of operation to be performed.

- 1 = Trim only
- 2 = Trim followed by maneuver (maneuver not to be restarted)
- 4 = Trim followed by maneuver (maneuver to be re-started)
- 5 = Maneuver restart
- 7 = Trim followed by rotorcraft stability analysis
- 8 = Retrieve maneuver data from tape for analysis

Within a single computer run, only one of the above operations may be specified. That is, data decks must not be stacked together into a single run. A more complete explanation of each NPART value is given below.

NPART = 1 Compute a trimmed flight condition only. See Figure 1. The NPRINT and NVARA inputs are not used. Subject to the IPL values, a data set of CARDS 02 through and including 234 must follow. The only cards which may follow CARD 234 are NPART = 10 cards (and their associated &CHANGE cards), and inputs to GDAP80.

NPART = 2 Compute a trimmed flight condition followed by a maneuver. See Figures 4 and 5. Subject to the IPL values, a data set of CARDS 02 through 291 (the time card) plus at least one 301-type card (J-card) must follow. The maneuver start time on CARD 291 is set to zero regardless of the input value.

The GDAP80 inputs follow the last J-card.

NPRINT Specifies the frequency of printout of maneuver data. The program prints data showing initial conditions for the maneuver (maneuver time t = 0) and for every NPRINTth time point thereafter. A blank or zero input is reset to unity.

The NVARA input is not used.

NPART = 4 Same as NPART = 2, except that the maneuver data will be stored so that it can be recalled at a later date for a maneuver restart (NPART = 5). See Figure 6. The use of this option will require the assistance of the local programmer to set up the restart tape.

NPART = 5 This is a maneuver restart case following the initial NPART = 4 case. See Figure 7. The local programmer should be consulted for at least the first case of this type. The complete data set for a maneuver restart is given in Table 3.

All program and iteration logic specified in the initial NPART = 4 run remains unchanged except that the TSTAB and TAIR groups or at least their identification cards must be included, regardless of the value of IPL(23) on the initial run. No &CHANGE cards are permitted.

The GDAP80 inputs are included, and may be changed between restarts.

NPART = 7 Compute a trimmed flight condition followed by a stability analysis. See Figure 2. The cards required are the same as for NPART = 1. An NPART = 10 card and GDAP80 inputs may follow CARD 234. Note that if the time-variant rotor analysis is activated for either rotor, a rotorcraft stability analysis cannot be performed. A stability analysis should not be performed for hover. That flight condition should be simulated with some small, nonzero, airspeed (typically, 0.001 knot).

TABLE 3. MANEUVER RESTART CASE

CARD 00	Message Card
CARD 01	NPART Card: enter 5 in Column 2.
CARD 02, 03, 04	IPSN and Comments
CARD 270	Stability Times Group: if the TSTAB group is not called from the Analytical Data Base, CARDS 281 and 282 must also be included.
CARD 280	BEA Data Printout Times Group: if the TAIR group is not called from the ADB, CARDS 281 and 282 must also be included.
CARD 291	Time Card: the start time is the time at which the maneuver is to be restarted; it must be greater than zero and less than the last time point of the maneuver being restarted. The time for restart need not be identically equal to a previous time point.
CARD 301, etc.	At least one maneuver command (J-card) is required.

The inputs to GDAP80 follow these inputs.

NPART = 8 This value of NPART causes data stored on tape to be loaded on the plot disk. See Figure 8. The local programmer should be consulted prior to its use. The value of NVARA on this card must not be equal to zero. The three comment cards (CARDs 02, 03, and 04) and the GDAP80 inputs constitute the remainder of the NPART=8 deck. Note that the IPSN on CARD 02 must be identical to the IPSN used in the run which created the tape.

Following a data set for trim only or trim-and-rotorcraft-stability analysis (NPART = 1 or 7), the parameter sweep option may be exercised by including an NPART = 10 card after CARD 234.

NPART = 10 This value of NPART permits the changing of user-selected inputs and retrimming the configuration. See Figure 3.

NVARA If NVARA = 0, the program will attempt only to iterate to a new trim condition (equivalent to NPART = 1); if NVARA $\neq$ 0, the program will attempt to trim and, if successful, will also perform a rotorcraft stability analysis (equivalent to NPART = 7).

The data set for NPART = 10 consists of the following cards:

First Card:	CARD 01	NPART card with NPART = 10
Subsequent card(s):	&CHANGE	Changes to input data using NAMELIST input as described below.

An NPART = 10 data set may be followed only by another NPART = 10 data set, and GDAP80 inputs.

The &CHANGE cards can be used to change the value of any input or inputs on CARDS 11 through 234 except for some of the program logic inputs, the rotor mode shapes, and the inputs to the airfoil data and rotor-induced velocity distribution tables.

The &CHANGE option cannot be used to change data in the fuselage aerodynamic tables, the rotor wake at surfaces tables or the XFSMS array.

Program logic inputs IPL(1-7) and IPL(9-24) must not be changed. These inputs control the initial reading

of data groups or blocks, and NAMELIST input is not capable of controlling the reading of additional groups or blocks.

If the switch for reading the rotor-induced velocity distribution table(s), IPL(12), is zero, it must not be changed. If it is not zero, it may be changed to any permissible value, i.e., 0, 1, 2, or 3. All other IPL values may be changed as desired.

The program assumes the last trim point is a good starting point for the next trim case. Therefore, the changes made should be reasonable (e.g., less than 20 to 30 knots in airspeed, 10 to 20 feet per second in rate of climb, less than 3 to 5 degrees in aerodynamic surface incidence). The larger the number of simultaneous changes made, the smaller the individual changes should be. If the changes are too large and XFC(5-12) and XFC(15-20) are not updated by the user, the chances of achieving a new trim are slim.

CARD 02 (Comment Card No. 1)

IPSN is a numeric title for the data set for identification purposes. It is printed in the output heading. The remainder of the card contains alphanumeric identifying comments which are printed in output headings as data set identification. Include it only when NPART = 1, 2, 4, 5, 7, or 8.

CARD 03 (Comment Card No. 2)

This card also contains alphanumeric comments which are included in the output headings. Include it only when NPART = 1, 2, 4, 5, 7, or 8.

CARD 04 (Comment Card No. 3)

The card also contains alphanumeric comments. Include it only when NPART = 1, 2, 4, 5, 7, or 8.

4.3 PROGRAM LOGIC GROUP

CARD 10 is the identification (ID) card for the Program Logic Group. If the Analytical Data Base is available, the ID card may call one of several standard sets of program logic from the ADB, and CARDS 11-17 must then be omitted.

CARDS 11-17 contain the bulk of the program logic controls. All the IPL inputs are integers (14I5 format). The logic inputs control the data groups which must be included in the input data, the program options to be used (such as unsteady aerodynamics, time-variant rotor analysis, etc.), and the data to be output. The logic has been chosen so that for the simplest cases most inputs are zero. In general, nonzero inputs activate the options and/or necessitate inputs of additional data.

For the options related to the rotors, a 0-1-2-3 type logic switch is used wherever possible. This type of switch operates in the following manner:

0 turns the option off for both rotors;

1 turns the option on for Rotor 1 only;

2 turns the option on for Rotor 2 only;

3 turns the option on for both rotors.

The discussion of the individual Program Logic inputs follows a description of the numerical procedures incorporated in AGAP80. Default values for those Program Logic Group inputs that have defaults are listed in Table 4.

4.3.1 Numerical Solution Techniques

Three numerical techniques are used in C81 to solve the rotorcraft equations of motion. The quasi-static procedure is used to solve a set of nonlinear algebraic equations to minimize the difference between the sum of forces and moments at the rotorcraft center of gravity and horsepower and a desired set of forces and moments and horsepower specified by the user. This iterative solution procedure is described in more detail in Sections 4.3.1.3 and 4.3.1.4.

The time-variant procedure is used to forward-integrate a set of nonlinear differential equations. A four-step Runge-Kutta method is used to integrate the equations in time (or azimuth) from an established initial condition.

Simpson's Rule is used to radially integrate the blade loading, providing the shears and moments at the root end of each blade.

TABLE 4. DEFAULT VALUES FOR THOSE PROGRAM LOGIC GROUP INPUTS THAT HAVE DEFAULTS

IPL	Default Value
1	1
4	20
5	3
6	1
7	1
45	5
60	5
61	5
77	root
78	root

All other Program Logic Inputs have no default values.

The user has some flexibility in selecting the solution techniques to be used for different sets of equations in both the trim and maneuver portions of the program.

4.3.1.1 Trim Solutions

The user can select the method by which the rotor equations are solved. The choices are:

1. Quasi-static Trim (QS)

   IPL(49) = 0

2. Quasi-static Trim followed by Time-variant Trim (QS-TV)

   IPL(49) ≠ 0, IPL(50) = 0

3. Fully-time-variant Trim (FTV)

   IPL(49) ≠ 0, IPL(50) = 2

In all cases, the six-degree-of-freedom airframe equations are solved using the iterative, algebraic quasi-static procedure described in Section 4.3.1.3.

If the user sets IPL(49) = 0, then the response of both rotors is also determined using the quasi-static analysis, as described in Section 4.3.1.4.

The rotors are also analyzed using the quasi-static procedure whenever IPL(49) ≠ 0 and IPL(50) = 0. Once a trimmed flight condition has been determined, either one (IPL(49) = 1 or IPL(49) = 2) or both rotors (IPL(49) = 3) are further analyzed using the time-variant procedure. In this subsequent analysis, the aircraft attitudes and rates and the control positions, are held constant, and XIT(6) rotor revolutions are computed for the selected rotor (or rotors).

The fully-time-variant trim (IPL(49) ≠ 0, IPL(50) = 2) generally provides a more refined set of trim conditions and usually requires significantly more computer time (by a factor of 3 to 5) than the other two trim procedures. This procedure is almost identical to the purely quasi-static trim procedure (IPL(49) = 0) except that the time-variant method is used to solve the equations of motion for one or both rotors for each iteration of the airframe-equations solution.

Whatever rotor solution procedure is selected is also used during the calculation of the partial derivative matrix.

4.3.1.2 Maneuver Solutions

There are eight separate solution technique combinations that can be used for a maneuver simulation. The user can independently select

1. A time-variant solution of the six-degree-of-freedom nonlinear differential equations of motion for the rigid body aircraft (IPL(56) = 0) or no solution of the airframe flight path equations (IPL(56) ≠ 0).

2. A quasi-static or time-variant solution of the equations of motion for Rotor 1.

3. A quasi-static or time-variant solution of the equations of motion for Rotor 2.

The fuselage degrees-of-freedom will be locked out (IPL(56) ≠ 0) for a simulation of a maneuver in wind-tunnel mode (IPL(1) = 11). A maneuver can generally be run in the least computer time with the time-variant procedure being used for both rotors (IPL(49) = 3).

4.3.1.3 Quasi-Static Procedure

The quasi-static, iterative algebraic solution procedure available in AGAP80 is a modified multi-variable Newton-Raphson technique for solving the trim equations. The method operates on a vector based on the trim imbalances and the partial derivative matrix. These are defined as

VAR(I)	the vector containing the current value of the independent variables
ERROR(J)	the vector containing the values of the difference between the desired value of the constraint quantity and the current value of the constraint quantity.
PDM(I,J)	the matrix of partial derivatives of the i^{th} constraint quantity with respect to the j^{th} independent variable
CORR(I)	the vector of corrections to the independent variables computed from the ERROR vector and the PDM matrix

The correction vector is computed by premultiplying the negative of the error vector by the inverse of the partial derivative matrix. The relationship is

$$\mathrm{CORR(I)} = -\sum_{J=1}^{NDOF} \mathrm{PDMI(J,I)} * \mathrm{ERROR(J)}$$

where NDOF is the number of degrees of freedom and PDMI(J,I) is the inverse of the PDM matrix.

The absolute value of each component of the correction is compared with a limiting value for that component that is determined by the variable damper logic (see the description of the Iteration Logic Group, Cards 222 through 227). Should the absolute value of a particular term be larger than its corresponding limiting value, then the entire CORR vector is multiplied by that limiting term divided by the absolute value of the correction term. This procedure ensures that each term in the correction vector is less than the limiting terms.

After CORR(I) is computed, and modified by the numerical variable damper, it is added to VAR(I) to create the initial state vector for the next trim iteration. The iterations continue, with the partial derivative matrix being recomputed periodically, until the absolute value of each of the components of the ERROR vector is less than the allowable error for that component.

4.3.1.4 Quasi-static and Time-variant Procedures for Rotors

The quasi-static solution procedure for a rotor analyzes the hub shears and moments for a rotor blade at each of twelve uniformly distributed azimuth positions. The resulting twelve sets of shears and moments are added appropriately and transformed into the nonrotating, shaft-axis coordinate system. The magnitudes of these nonrotating hub shears and moments are divided by twelve, multiplied by the number of rotor blades, transformed into the body-axis coordinate system, and summed into the forces and moments at the airframe center of mass, using the appropriate moment arms.

This solution procedure permits only one-per-rev response of the rotor. If no elastic modes were input for the rotor, the solution would be comprised of rigid-body flapping only. If elastic rotor modes were input, each responds solely at one-per-rev.

The time-variant procedure determines the hub shears and moments for each of the XMR(1) (or XTR(1)) blades. The full nonlinear equations of motion are solved for each blade, starting with an

initial estimate of the rotor one-per-rev response defined by the flapping angles. The solution permits response at harmonics higher than one-per-rev. In the trim analysis, the rotor response usually reaches a steady state harmonic solution in three to seven rotor revolutions.

4.3.2 Program Logic Group Inputs

CARD 11 Input Control Logic

The eight types of quasi-static trim that are currently available are selected by the proper choice of IPL(1). The independent variables used for each of these trims are listed in Table 5, while Table 6 contains a list of the constraints imposed for each of these trims. The user should note that the values of IPL(3), IPL(44), IPL(51) and IPL(52) also have some control over the independent variables and constraints used in the trim. If IPL(1) = 11, the data deck may include only the following groups:

- CARDS 00 through 17 (Identification and Program Logic)
- Data tables specified by IPL(2)
- Rotor 1 Group
- Rotor 1 Elastic Pylon Group (If IPL(9) $\neq$ 0)
- Rotor 1 Elastic Blade Data Group (if IPL(6)>0)
- Rotor Aerodynamic Group
- Rotor 1 Induced Velocity Distribution Table (if IPL(12)>0)
- Rotor Controls Group
- Iteration Logic Group
- Flight Constants Group
- Five Maneuver-Only Groups (i.e., Bobweight, Weapons, SCAS, STAB Times, and Blade Element Data Times Groups) (if IPL(23) $\neq$ 0)
- GDAP80 inputs

If NPART = 1 or 7, the five maneuver-only groups must be omitted; if NPART = 2 or 4, IPL(23) controls the reading of these five groups. IPL(1) = 11 overrides the inputs for IPL(3) and (15-21).

IPL(2) specifies the total number of airfoil data tables included in the input deck. Permissible inputs are 0 through 10. Note that if a rotor aerodynamic subgroup specifies that it uses an airfoil data table, the corresponding table must be input and that reading a table does not necessarily mean that it will be used (see the Airfoil Data Table Group, Section 4.4, and the Rotor Aerodynamic Group, Section 4.11).

TABLE 5. INDEPENDENT VARIABLES USED IN EACH TRIM OPTION.

Value of IPL(1)	0,1	2	3	4	5	6[1]	7	8	9[2]	10[2]	11
Trim Type / Independent Variable	Standard Trim	Symmetric Maneuver	Banked Turn	Constant Power	Constant Collective	Constant Sideslip and Horsepower	Constant Pedal and Horsepower	Longitudinal Trim	Longitudinal Trim with Lateral Force Balance	Simplified Longitudinal Trim	Rotor Only
Collective Stick	X	X	X	X		X	X	X	X	X	
Longitudinal Cyclic Stick[2]	X	X	X	X	X	X	X	X	X	X	3
Lateral Cyclic Stick[2]	X	X	X	X	X	X	X				3
Pedal[2]	X	X	X	X	X	X					
Euler Yaw Angle	4	4	4	4	4	4	4				
Euler Pitch Angle	X	X	X	X	X	X	X	X	X		
Euler Roll Angle	4	4	4	4	4	4	4				
Rate of Climb				X	X	X	X				
Rotor 1 Longitudinal Flapping Angle[2] [5]	X	X	X	X	X	X	X	X	X	X	3
Rotor 1 Lateral Flapping Angle[2] [5]	X	X	X	X	X	X	X	X	X	X	3
Rotor 2 Longitudinal Flapping Angle[2] [5]	X	X	X	X	X	X	X				
Rotor 2 Lateral Flapping Angle[2] [5]	X	X	X	X	X	X	X				

TABLE 5. Concluded.

Notes

1. The options controlled by IPL(1) = 6, 9 or 10 are not yet operable.

2. The rotor flapping equations can be decoupled during trim by inputting nonzero values of IPL(51) and IPL(52) as follows:

IPL(51) > 0;	the cyclic stick positions are changed to rebalance the rotor while the Rotor 1 flapping angles are held constant.
IPL(51) < 0;	the Rotor 1 flapping angles are changed to rebalance the rotor while the cyclic stick positions are held constant.
IPL(52) > 0;	the cyclic stick positions are changed to rebalance the rotor while the Rotor 2 flapping angles are held constant.
IPL(52) < 0;	the Rotor 2 flapping angles are changed to rebalance the rotor while the cyclic stick positions are held constant.

In any of these four possibilities, the two independent variables are removed from the analysis. If both IPL(51) and IPL(52) are nonzero, then four independent variables are removed. If the user is analyzing a tandem or side-by-side rotorcraft, IPL(51) and IPL(52) should not be positive simultaneously. Setting both values positive would cause the program to try to solve four equations (longitudinal and lateral flapping on each rotor) with only two variables (longitudinal and lateral cyclic stick position).

3. The user must input a nonzero value of IPL(51) when IPL(1) equals 11. The two independent variables are then either the cyclic stick positions or the rotor flapping angles.

4. If IPL(44) = 0, then Euler roll angle is an independent variable. If IPL(44) ≠ 0, then the Euler yaw angle is an independent variable. The direction of a banked turn (IPL(1)=3) is defined by the sign of the Euler roll angle (XFC(5)); a positive roll angle input indicates a right turn.

5. If either rotor is deleted from the analysis (IPL(3) > 0), then the flapping angles for the rotor are not independent variables.

TABLE 6. CONSTRAINT EQUATIONS FOR EACH TRIM OPTION.

Value of IPL(1)	0,1	2	3	4	5	6[1]	7	8	9[1]	10[1]	11
Trim Type / Constraint Equation	Standard Trim	Symmetric Maneuver	Banked Turn	Constant Power	Constant Collective	Constant Sideslip and Horsepower	Constant Pedal and Horsepower	Longitudinal Trim	Longitudinal Trim with Lateral Force Balance	Simplified Longitudinal Trim	Rotor Only
Body Longitudinal Force Balance	X	X	X	X	X	X	X	X	X	X	
Body Lateral Force Balance	X	X	X	X	X	X	X				
Body Vertical Force Balance	X	X	X	X	X	X	X	X	X	X	
Body Yawing Moment Balance	X	X	X	X	X	X	2				
Body Pitching Moment Balance	X	X	X	X	X	X	X	X	X		
Body Rolling Moment Balance	X	X	X	X	X	X	2				
Engine Horsepower				X		X	X				
Rotor 1 Longitudinal Flapping Moment Balance[3]	X	X	X	X	X	X	X	X	X	X	X
Rotor 1 Lateral Flapping Moment Balance[3]	X	X	X	X	X	X	X	X	X	X	X
Rotor 2 Longitudinal Flapping Moment Balance[3]	X	X	X	X	X	X	X				
Rotor 2 Lateral Flapping Moment Balance[3]	X	X	X	X	X	X	X				

TABLE 6. Concluded

<u>Notes</u>

1. The options controlled by IPL(1) = 6, 9 or 10 are not yet operable.

2. Either the yawing moment or the rolling moment is balanced when IPL(1) = 7, dependent upon the value of IPL(44). If IPL(44) = 0, no attempt is made to balance the yawing moment, while an imbalance is permitted in the rolling moment if IPL(44) > 0.

3. The rotor flapping moments are not balanced if that rotor is deleted from the analysis (IPL(3) > 0).

IPL(3) deletes the reading of specified rotor groups. It is a 0-1-2-3 type switch, e.g., 0 requires input of both rotor groups (none deleted) and 3 requires deletion of both groups. When a group is deleted, its ID card must also be deleted.

IPL(4) specifies the number of blade segments for Rotor 1. If the value of IPL(4)>0, then the segments are of uniform length. No more than 20 blade segments can be used for Rotor 1. If the analysis includes an elastic rotor (IPL(6)>0), IPL(4) must be equal to the number of blade segments for which modal displacements are given. The default value for IPL(4) is 20 equal segments.

IPL(5) specifies the number of blade segments for Rotor 2. If the value of IPL(5)>0, then the segments are of uniform length. No more than 20 segments can be used for Rotor 2. If the analysis includes an elastic rotor (IPL(7)>0), IPL(5) must be equal to the number of blade segments for which modal displacements are given. The default value for IPL(5) is 3 equal segments in order to reduce computer run time.

For both IPL(4) and IPL(5), the minimum number of segments for a rotor without elastic inputs is 3. If at least one rotor mode shape is input, a one-segment blade may be represented. It is recommended, though, that at least 5 segments be used. If fewer segments are to be used, set the hub extent to zero and the tip loss factor to 1.0 for that rotor.

For positive, nonzero inputs, the values of IPL(6) and IPL(7) specify the number of mode shapes which must be included in the Rotors 1 and 2 Elastic Blade Data Groups, respectively. IPL(6) and (7) control the reading of the elastic blade data sets for Rotors 1 and 2, respectively. If IPL(6) = 0, all Rotor 1 elastic blade data (weight, inertia, and mode shape distributions on CARDS 50, 51, etc.) must be omitted from the input deck and the proper values of weight and inertia must be input in the rotor groups. Similarly, if IPL(7) = 0, all Rotor 2 elastic blade data (CARDS 80, 81, etc.) must be omitted. The user should try to input the correct first mass moment for the rotor (XMR(42) or XTR(42)) if at all possible.

Up to 11 blade modes may be input for each rotor with a total of 12 blade modes. Note that inputting blade mode shapes does not necessarily imply coupling between the blade dynamics and aerodynamics. The rotor may be elastic without being aeroelastic. See the description of IPL(49) and IPL(50). If elastic blade data are included, the blade weight and inertia inputs in the corresponding rotor group(s) are ignored.

IPL(8) is currently unused.

IPL(9) controls the reading of the Rotor 1 Elastic Pylon Group (the 40-series of cards). The absolute value of IPL(9) is the number of mode shapes, while its algebraic sign denotes whether or not the mode shapes were generated with the rotor mass on the mast (IPL(9)>0) or not (IPL(9)<0). If IPL(9) = 0, the Rotor 1 Elastic Pylon Group is not read. Note that the user can only input 4 elastic pylon modes when the flightpath stability analysis is to be activated. Otherwise, up to 10 elastic pylon modes may be included.

IPL(10) controls the reading of the Rotor 2 Elastic Pylon Group in a manner identical to that of IPL(9).

IPL(11) specifies the total number of rotor airfoil aerodynamic subgroups included in the Rotor Aerodynamic Group. Permissible inputs are 0 to 10 inclusive. As long as the input data includes at least one rotor group, an input of 0 is reset to 1 and one subgroup must be input. If both rotors are deleted (IPL(3) = 3), IPL(11) may be input as zero to delete the reading of the Rotor Aerodynamic Group in its entirety.

IPL(12) controls the reading and use of the Rotor-Induced Velocity Distribution (RIVD) tables that are described in Section 4.12. It is a 0-1-2-3 type switch. That is, if IPL(12) = 0, both the Rotor 1 and Rotor 2 RIVD tables must be omitted; if IPL(12) = 1, the Rotor 1 table must be input and Rotor 2 table omitted; if IPL(12) = 2, the Rotor 2 table must be input and the Rotor 1 table omitted; if IPL(12) = 3, both tables must be input. If a table is not input for a particular rotor, an empirically derived equation is used to compute the distribution for that rotor. This default equation is given in Section 4.12.3.

IPL(13) specifies the number of RWAS (Rotor Wake at Aerodynamic Surfaces) tables which must be included in the deck. A maximum of 12 such tables is permitted. Note that the tables are numbered sequentially on input, that these sequence numbers are later used to call specific tables, and that reading in a table does not necessarily mean it is used. The format for each table is given in Section 4.13, and their use is discussed in Section 4.16.1 for the wing and Section 4.17.2 for the stabilizing surfaces.

IPL(14) is a 0-1-2-3 switch that controls the reading of the blade harmonic shaker and harmonic control motion cards.

CARD 12

IPL(15) controls the reading of the basic and aerodynamic inputs to the Wing Group (CARDS 140-14A) and the Wing Control Linkages Subgroup (CARDS 14B and 14C). If IPL(15) = 0, both

the Group and Linkages Subgroup must be omitted; if IPL(15)>0, both must be included. If IPL(15)<0, then CARDS 140-14A must be included and CARDS 14B and 14C must be omitted (i.e., the wing incidence and control surface deflection are independent of the flight controls).

IPL(16) controls the reading of the basic and aerodynamic inputs to the Stabilizing Surface Number 1 Group (CARDS 150-159) and the Stabilizing Surface Number 1 Control Linkage Subgroup (CARDS 15A and 15B). If IPL(16) = 0, the entire Stabilizing Surface Number 1 Group, including ID card and Linkage Subgroup, must be omitted. If IPL(16)>0, the Stabilizing Surface Number 1 Group and its Linkage Subgroup must be included. If IPL(16) <0, the Stabilizing Surface Number 1 Group is included, but the linkage subgroup must not be included (i.e., both the incidence angle and control surface deflection of Stabilizing Surface Number 1 are independent of the flight controls).

IPL(17), IPL(18), and IPL(19) control the reading of the Stabilizing Surface Number 2, Stabilizing Surface Number 3, and Stabilizing Surface Number 4 Groups and their respective Linkage Subgroups as described for IPL(16).

IPL(20) controls the reading of the Jet Group. If IPL(20) = 0, the entire Jet Group including ID card must be omitted; otherwise it must be included.

IPL(21) controls the reading of the External Store/Aerodynamic Brake Group (CARDS 200-204C) and is equivalent to the number of store/brake subgroups which are to be included. If IPL(21) = 0, the entire group, including the identification card, must be omitted. If IPL(21)>0, the group must include the identification card and the specified number of subgroups; e.g., if IPL(21) = 3, the group must consist of 10 cards (one identification card plus three subgroups of three cards each).

IPL(22) controls reading of the Supplemental Rotor Control Subgroup (CARDS 215-218). If IPL(22) = 0, the subgroup must be omitted; otherwise it must be included.

IPL(23) controls the reading of the Bobweight, Weapons, SCAS, Stability Times, and Blade Element Printout Groups when NPART = 2 or 4. If IPL(23) = 0, all five groups must be omitted; if IPL(23) ≠ 0, all five must be included. If NPART does not equal 2 or 4, all the groups must be omitted. This input affects the reading of the last two groups when NPART = 5.

IPL(24), IPL(25) and IPL(26) are currently inactive.

IPL(27) controls the position of the rotor blades for side-by-side folding rotor configurations. It should be input as zero for all other rotor configurations. If IPL(27) = 0, both rotors are defined to be unfolded and turning at the rpm determined by XMR(13) and XFC(25) for Rotor 1 and XTR(13) and XFC(25) for Rotor 2. If IPL(27) $\neq$ 0, the rotors are defined to be stopped and folded; in this case, the data should be set up as if the rotors were unfolded and at normal RPM except that:

(1) IPL(27) $\neq$ 0.0

(2) Controls are locked by setting XCON(4), XCON(11), XCON(18), and XCON(25) $\neq$ 0.0

(3) Maneuver input cards for J = 18 and J = 27 have a time of 0.0, i.e., for J = 18, $\Omega_B > 0$

IPL(28) controls the cg shift with rotor folding. If IPL(28) = 0, no shift is computed; $\neq$ 0, cg shift is computed. This single switch applies to both rotors.

CARD 13

If IPL(29) = 0, then the fuselage aerodynamics will be represented using the equations. If IPL(29) $\neq$ 0, then the fuselage aerodynamic table must be input and will be used instead of the equations. The remainder of the inputs on this card are currently inactive.

CARD 14

IPL(43) is currently inactive.

IPL(44) controls the Euler angle held constant during the TRIM procedure. If IPL(44) = 0, the TRIM procedure holds the yaw angle constant. It is necessary to hold yaw constant for low speed or hover cases, since the force and moment derivatives with yaw angle all go to zero in hover. If IPL(44) $\neq$ 0, the TRIM procedure holds the Euler roll angle constant and iterates on pitch and yaw. This tends to give the most realistic TRIM conditions at high speeds, since a pilot has a more sensitive feeling for a roll angle than a yaw angle. Generally, the program trims more readily to a given yaw angle. If IPL(1) specifies a coordinated turn, the TRIM procedure iterates on pitch and yaw regardless of the value of IPL(44).

IPL(45) controls the computation of the partial derivative matrix during trim. Permissible values are 0, 1, 2, 3, 4, and 5. If IPL(45) = 0, the matrix is computed every fifth itera-

tion, i.e., iterations 1, 6, 11, ... etc., and uses the most recently computed matrix for iterations in which the matrix is not computed. If IPL(45) $\neq$ 0, the matrix is computed every IPL(45)th iteration. Computing the matrix for every iteration rather than for every fifth iteration will substantially increase the run time for trim. Computation at every iteration is normally necessary only when there is difficulty getting a case to trim with IPL(45) = 0. In general, odd number inputs for IPL(45) work better than even numbers.

IPL(46) controls the steady state aerodynamics used for Rotor 1. If IPL(46) $>$ 0, the IPL(46)th Rotor Airfoil Aerodynamic (RAA) Subgroup is used to compute the Rotor 1 aerodynamic coefficients at all blade stations (i.e., the blade has a constant airfoil section root to tip). If IPL(46) = 0, it is reset to 1. If IPL(46) $<$ 0, the main Rotor 1 blade airfoil distribution card, CARD 3P, is read and used to assign the RAA subgroups to Blade Stations Number 1 through IPL(4). CARD 3P must be omitted if IPL(46) $\geq$ 0 and must be included if IPL(46) $<$ 0.

IPL(47) controls the steady state aerodynamics used for Rotor 2 in the same manner as IPL(46) controls the Rotor 1 aerodynamics. However, the sign of IPL(47) controls the reading of only the Rotor 2 airfoil distribution, CARD 6P, and has no effect on CARD 3P, just as IPL(46) has no effect on reading CARD 6P. Note that both IPL(46) and (47) must be less than or equal to IPL(11), the number of RAA subgroups.

IPL(48) controls which option is to be used for rotor unsteady aerodynamics. It is a 0-1-2-3 type switch with the added feature that positive values activate the UNSAN unsteady aerodynamic model for the specified rotor(s) while negative values activate the BUNS unsteady aerodynamic model. See Volume I of Reference 1 for discussion of these two models. If IPL(48) = 0, unsteady aerodynamics are ignored in the rotor computations. If an option is activated, it is activated for all blade segments not included in the rotor hub. Even if activated, neither option will affect computation unless the time-variant rotor analysis discussed below is used.

The program includes the option for two basic types of rotor solution procedure where each type has two possible blade representations:

Type I:	Quasi-static with (A) rigid blades or (B) elastic blades
Type II:	Time-variant with (A) rigid blades or (B) elastic blades

IPL(49) specifies the rotor(s) for which the time-variant solution procedure will be used and operates as a 0-1-2-3 type switch. If IPL(49) = 0 the time-variant procedure will not be used in any part of the program and the value of IPL(50) will be ignored. In this case, both rotors will use the quasi-static solution procedure for both trim and maneuver. Type IA will be used when no elastic blade data are input (IPL(6) or (7) = 0) and Type IB will be used for a rotor if the elastic blade data are input. If IPL(49) = 1 or 2, the Type II solution procedure will be used for the specified rotor and Type I will be used for the other rotor. If IPL(49) = 3, the Type II solution procedure will be used for both rotors. Should the user request the time-variant solution procedure for a rotor for which rotor mode shapes were not input, the program internally generates a rigid body flapping mode.

Note that if IPL(49) ≠ 0, the rotorcraft stability analysis cannot be performed. That is, NPART must not equal 7, and either the TSTAB group must be omitted or the TSTAB(1) input must be greater than the duration of the maneuver. The TSTAB group is discussed in Section 4.26; also see IPL(23).

If IPL(49) ≠ 0, then IPL(50) controls the portion of the program in which the time-variant analysis is to be used for the rotor(s) specified by IPL(49). Table 7 shows the type of rotor analysis used for each rotor as a function of the values of IPL(49) and (50). The azimuth increment for a rotor that uses the time-variant analysis is input on CARD 221, XIT(2), for trim and on CARD 291, TCI(2), for maneuver. The azimuth increment for a rotor that uses the quasi-static analysis is fixed at 30 degrees for both trim and maneuver. See Section 4.28 for additional information on TCI(2) as it applies to each type of rotor analysis during maneuver.

The time-variant portion of a quasi-static trim followed by a time-variant trim (a QS-TV trim; IPL(50) = 0) is in essence a time history of XIT(6) rotor revolutions with the fuselage and control positions locked. For each rotor which is time-variant, the additional run time for the time-variant trim after the quasi-static trim will be about the same as the time for a maneuver of XIT(6) rotor revolutions.

For a fully time-variant trim (IPL(50) = 2), each trim iteration will require about 3 to 6 times the run time of an equivalent quasi-static iteration, depending on azimuth increment and whether one or both rotors are time-variant. Additional run time must be allocated accordingly for a fully time-variant trim. However, it cannot be predetermined whether a fully time-variant trim will require more or fewer iterations than a corresponding quasi-static trim.

TABLE 7. ROTOR SOLUTION PROCEDURE USED DURING TRIM AND MANEUVER

Inputs			Solution Procedure Used	
IPL(49)	IPL(50)	Rotor	In Trim	In Maneuver
0	(Ignored)	1	QS	QS
		2	QS	QS
1	0	1	QS-TV	TV
		2	QS	QS
	1	1	QS	TV
		2	QS	QS
	2	1	FTV	TV
		2	QS	QS
2	0	1	QS	QS
		2	QS-TV	TV
	1	1	QS	QS
		2	QS	TV
	2	1	QS	QS
		2	FTV	TV
3	0	1	QS-TV	TV
		2	QS-TV	TV
	1	1	QS	TV
		2	QS	TV
	2	1	FTV	TV
		2	FTV	TV

QS = Quasi-static rotor solution procedure

TV = Time-variant rotor solution procedure

QS-TV = Quasi-static trim followed by a time-variant rotor solution. During the time-variant portion of this type trim, only the rotor and pylon elastic modes of the time-variant rotor are allowed to vary; the fuselage and control positions are held fixed at the values determined by the quasi-static trim. If both rotors are time-variant, they are analyzed independently of each other.

FTV = Fully time-varient rotor solution procedure.

IPL(51) and IPL(52) control the moment balancing procedures used for Rotor 1 and Rotor 2, respectively, during each individual trim iteration. Although virtually identical in operation, the two inputs are completely independent of each other. If IPL(51) and IPL(52) = 0, the standard, fully coupled 10 x 10 system of trim equations is used for each trim iteration. For the quasi-static rotor analysis (IPL(49) = 0) this means that the longitudinal and lateral flapping moments of each rotor are computed only once during a single trim iteration using the current values of cyclic pitch and flapping angles. That is, the rotor moments as calculated are used, and no attempt is made to reduce any moment imbalance during a trim iteration. The value of IPL(51) or IPL(52) is ignored during a time-variant trim of that rotor. IPL(51) = IPL(52) = 0 is considered to be the standard procedure for iterating to a trimmed flight condition regardless of the rotor analysis being used.

If the quasi-static rotor analysis is being used, nonzero values of IPL(51) and IPL(52) can be used to decouple sets of rotor flapping moment equations from the standard 10 x 10 system and to activate one of two alternate procedures for reducing the flapping moment imbalances in the uncoupled set(s) of rotor equations. Note that uncoupling a rotor may increase the run time of the case by 50 percent. The systems of equations to be used in each trim iteration are given in Table 8, assuming that IPL(1)=1.

TABLE 8. SYSTEMS OF EQUATIONS USED IN TRIM

IPL(51)	IPL(52)	Systems of Equations
= 0	= 0	One 10 x 10 system (both rotors and airframe)
≠ 0	= 0	One 2 x 2 system (Rotor 1) One 8 x 8 system (Rotor 2 and airframe)
= 0	≠ 0	One 2 x 2 system (Rotor 2) One 8 x 8 system (Rotor 1 and airframe)
≠ 0	≠ 0	Two 2 x 2 systems (one for each rotor) One 6 x 6 system (airframe)

NOTE: The user cannot decouple the rotor analysis if the fully-time-variant trim (IPL(49) = 1, IPL(50) = 2, for example) is being used.

When IPL(51) or IPL(52) is not equal to zero, the sign of the input determines which of the moment balancing procedures is to be used. If the input is greater than zero, flapping

angles are locked and cyclic pitch angles are changed to trim the appropriate set(s) of decoupled rotor equations. If the input is less than zero, the cyclic pitch angles are locked and the flapping angles are changed to trim the appropriate set(s) of decoupled rotor equations. The magnitude of the input specifies the maximum number of subiterations (rotor iterations within the trim iteration) that are permitted to trim the appropriate rotor. A system of decoupled rotor equations is defined to be trimmed when the magnitude of the moment imbalance is less than the allowable errors (XIT(50) and XIT(51) for Rotor 1, XIT(52) and XIT(53) for Rotor 2). Note that IPL(51) and (52) control only rotor moment balancing procedures. The allowable errors for the force and moment summary, XIT(57) through XIT(63), do not affect rotor moment balancing during a single trim iteration.

IPL(53) and IPL(54) are currently inactive.

IPL(55) controls the use of the Wagner function for the time delay of lift buildup on the wing (See Section 5-7 of Reference 3).

- = 0 function is inactive
- = 1 function active only for the first value of the time increment on CARD 291
- = 2 function active only for the second value of the time increment on CARD 291

IPL(56) controls the fuselage degrees of freedom in maneuvers. If IPL(56) = 0, the fuselage has the conventional six degrees of freedom. If IPL(56) ≠ 0, all fuselage degrees of freedom are suppressed (locked out) during maneuvers. Although this input is independent of all other logic inputs, it is normally used only for wind tunnel simulations, e.g., IPL(1)=11, IPL(51) or IPL(52) ≠ 0.

CARD 15

IPL(57) through IPL(59) are currently inactive.

If Rotor 1 has been decoupled (IPL(51)≠0), the program will compute a partial derivative matrix for the 2x2 set of equations every IPL(60) rotor iterations. The default value is 5. IPL(61) performs the same function for Rotor 2 whenever it is decoupled (IPL(52)≠0).

IPL(62) through IPL(70) are currently inactive.

---

[3]Bisplinghoff, Raymond L., Ashley, Holt, and Halfman, Robert L., AEROELASTICITY, Addison-Wesley Publishing Company, Reading Massachusetts, 1955, pp. 281-293.

CARD 16 Output Control Logic

IPL(71) controls the formal printout of input data which normally precedes the start of the first TRIM iteration. Increased values of IPL(71) progressively suppress more and more data as indicated below:

Value of IPL(71)	Printout Suppressed
= 0	None
$\geq$ 1	All data tables (airfoil, elastic blade, RIVD, and RWAS tables)
$\geq$ 2	All group ID cards (except Program Logic Group) and all input groups (printout of &CHANGE Cards is not suppressed)
$\geq$ 3	Problem heading and identifying comments (from CARDS 02, 03, and 04) when NPART = 10; &CHANGE Card(s) and input data for maneuvers in all cases

Printout of the problem heading, identifying comments, and Program Logic Group ID cannot be suppressed on the first case in a run because these data are printed before the IPL group is read in. The data deck listing printout at the start of each run is never suppressed. Note that in the second and subsequent cases in a parameter sweep (i.e., when NPART = 10), printout of all data tables is automatically suppressed. To print out the tables in these cases, IPL(71) must be reset to zero in the &CHANGE card of each case for which the print is desired.

IPL(72) controls the printout of the trim iteration data as follows:

IPL(72) = 0	Rotor data and force and moment summary from last iteration only. Last partial derivative matrix computed. A harmonic analysis of the response of modes 2 through 11 is printed for the last iteration.
$\geq$ 1	Iteration heading (with QS or TV notation); time-variant heading and dependent participation factor for time-variant iteration; force and moment summary for each iteration and partial

derivative matrix when calculated. The harmonic response of modes 2 through 11 is printed out.

≥ 2	Rotor data, Force and Moment Summaries, and Dependent Participation Factors (if applicable) during Partial Derivative Matrix calculations during TRIM. Rotor data and Force and Moment Summaries during the calculation of the Control Power Partial Derivative Matrices during STAB. Rotor and pylon moments and angles and rotor balance parameters (if applicable) during TRIM, STAB and MANEUVER. The harmonic response of modes 2 through 11 is printed out.

IPL(73) controls the printout of the optional trim page. It is a 0-1-2-3 type switch; e.g., 0 omits the optional page for both rotors and 3 prints one of the optional trim pages for each rotor.

If IPL(74)>0, the Force and Moment Summary will be presented in the wind-axis coordinate system as well as the body-axis coordinate system.

IPL(75) controls printout of blade element aerodynamic (BEA) data for Rotor 1 as follows:

IPL(75) = 0 or 1	No BEA data are printed
≥ 2	BEA data are printed along with bending moment data at the maneuver time points specified in the Blade Element Data Printout Group. (See Section 4.27). If no maneuver is computed, IPL(75) $\leq$ 2 has no effect.
≥ 3	BEA data are printed after a QS trim and along with bending moment data at the maneuver time points specified in the Blade Element Data Printout Group.

WARNING: IPL(75) should never be set larger than 3 for a normal run. IPL(75) inputs of 4, 5 and 6 are intended only for very detailed diagnostic checks by the programmer; these values will generate huge stacks of output containing data which is not needed for normal runs. For reference only, the effects of values of 4, 5, and 6 are as follows:

IPL(75) $\geq$ 4 BEA data are printed after QS trim and at <u>every</u> time point in a maneuver <u>regardless</u> of the value of NPRINT on <u>CARD 01</u> and the values in the Blade Element Data Printout Group.

$\geq$ 5 The virtual work and its components for each mode shape of each blade of each rotor are printed at each iteration in trim and at every time point in maneuver.

$\geq$ 6 BEA data are also printed for each rotor revolution in trim. The output generated by this value of IPL(75) is extremely voluminous.

<u>NOTE</u>: Blade-element aerodynamic data will not be printed if Rotor 1 is time-variant (IPL(50) = 1 or 3). The GDAP80 contour plot option should be used to print out aerodynamic quantities for a time-variant rotor.

IPL(76) controls printout of blade element aerodynamic (BEA) data for Rotor 2 as described for Rotor 1 in the description of IPL(75). These diagnostics will not be printed for Rotor 2 if it is time-variant (IPL(50) = 2 or 3). Use the contour plot option to print out Rotor 2 aerodynamics in this case.

IPL(77) and IPL(78) are used to select the blade station at which the beamwise, chordwise, and torsional moments are output at each time point in a time-variant maneuver, for Rotors 1 and 2, respectively. There are up to 20 blade stations numbered sequentially from 0 at the hub (zero radius) to 19 at the next-to-last station. (The moment at 100-percent radius is always zero.)

IPL(79) controls the storing of certain quasi-static trim rotor variables for tabulation and contour plots. See Section 5.7 for a listing of the data stored and instructions for printing the data. Data are stored in one Postprocessing Data Block for blade one for both rotors during quasi-static trim whenever IPL(79)$\neq$0.

IPL(80) through IPL(83) are currently inactive.

IPL(84) controls the printout of the modal participation factors during Time-Variant Trim. If IPL(84) = 0, the participation factors are printed out regardless of the value of IPL(72). If IPL(84) $\neq$ 0, the participation factors are not printed.

CARD 17

IPL(85), (86), (87), and (88) provide the user with control over the coupling in the rotorcraft stability analysis (STAB). Some graphical examples of the effect of IPL(85), (86), and (87) on the matrix used in STAB are shown in Figure 21. These three switches are completely independent of each other. IPL(85) controls the coupling between the three longitudinal fuselage equations and the three lateral fuselage equations. If IPL(85) = 0, the fuselage is represented by two 3 x 3 matrices. If IPL(85) ≠ 0, the fuselage is represented by a 6 x 6 matrix.

IPL(86) controls the rotor dynamic pylon degrees of freedom in STAB. It is a 0-1-2-3 type switch. If IPL(86) = 3, the pylon degrees of freedom for both rotors are included explicitly. If IPL(86) is zero, the pylon degrees of freedom do not appear in the rotorcraft stability analysis. IPL(86) must be compatible with the pylon data read in by IPL(9) and IPL(10). As a safeguard, the program resets IPL(86) to zero if IPL(9), IPL(10), and IPL(86) are incompatible.

IPL(87) controls the rotor flapping degrees of freedom in STAB. It is a 0-1-2-3 type switch. If IPL(87) = 3, the rotor flapping equations appear explicitly in the rotorcraft stability analysis. In this case all partial derivatives are made without changing the flapping angles. If IPL(87) = 0, the rotor effects enter the rotorcraft stability analysis by adjusting the flapping angles to a new stabilized position for each partial derivative. See Figure 22 for logic flow on the STAB partial derivatives.

If the flapping degrees of freedom are excluded by IPL(87), these degrees of freedom can be included in the stability derivatives by changing the flapping angles to rebalance the rotors. If IPL(88) = 0, the rotor(s) will be rebalanced; if IPL(88) ≠ 0, no rebalancing takes place. This option is intended to be used for diagnostic purposes, not to represent a real rotorcraft.

IPL(89) controls the option to print or punch on cards the mass, damping, and stiffness matrices used in the rotorcraft stability analysis. The punch option is useful when the user plans to input these matrices to another computer program.

IPL(89) = 0 to print only
1 to punch only
2 to print and punch
3 to suppress print and punch

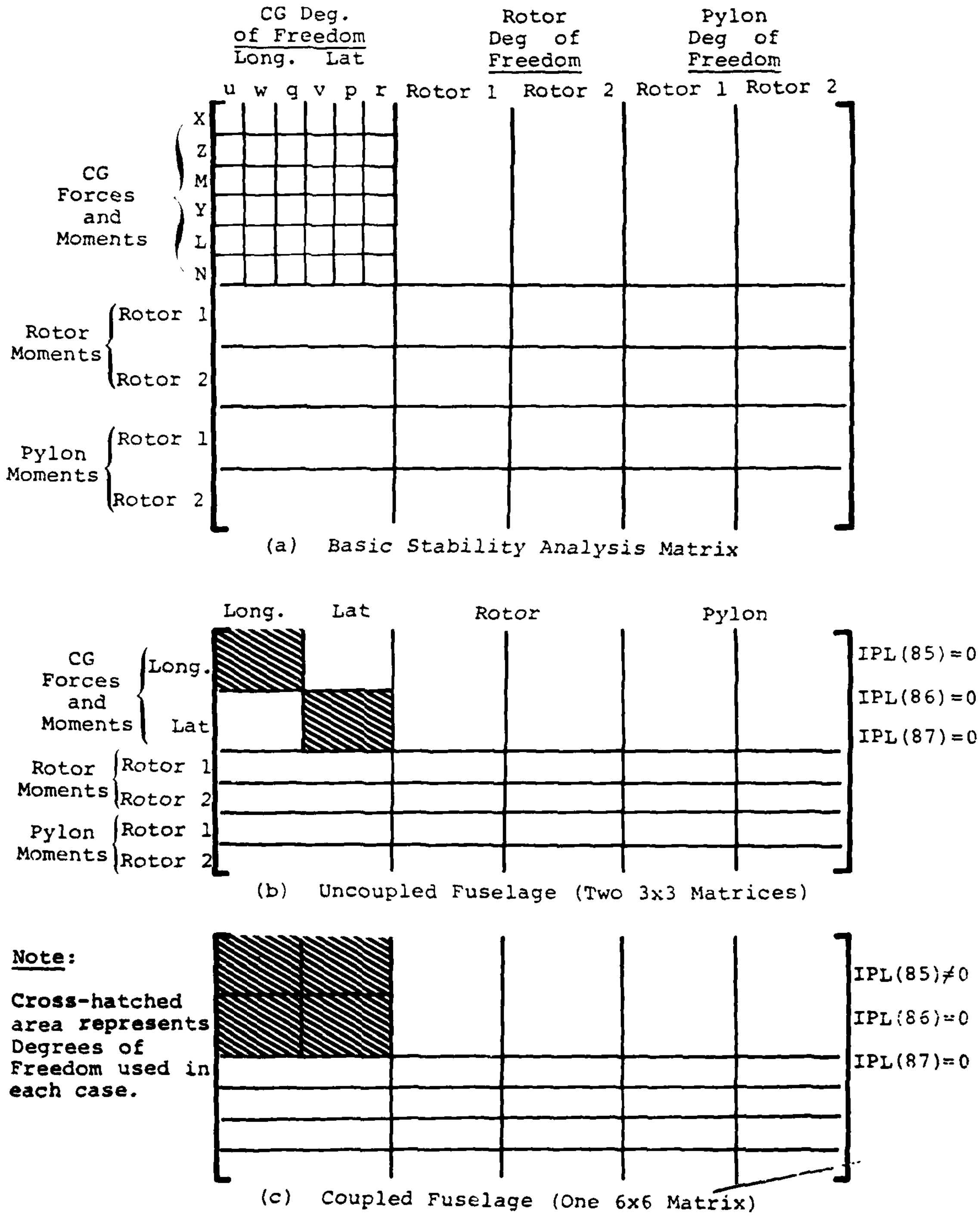
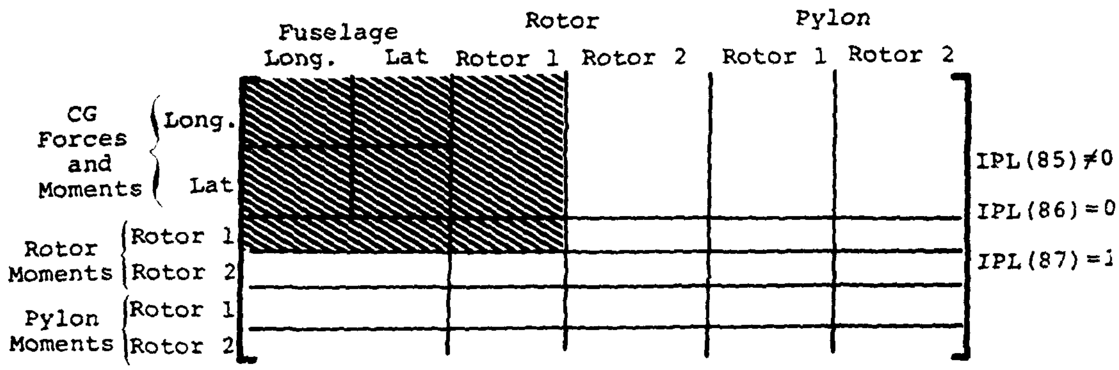
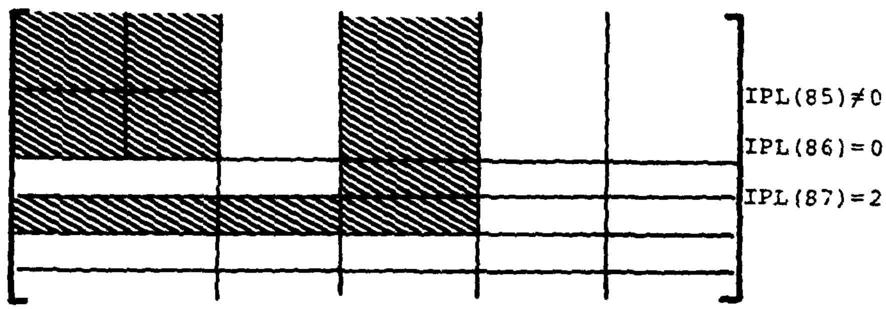


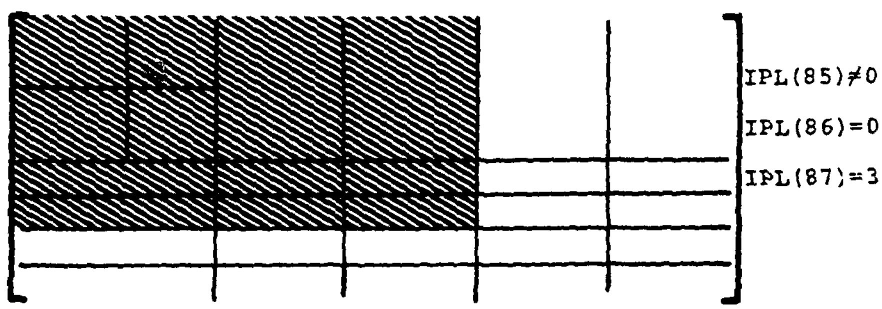
Figure 21. Schematic of Matrices Used in the Rotorcraft Stability Analysis.



(d) Coupled Fuselage - Rotor 1

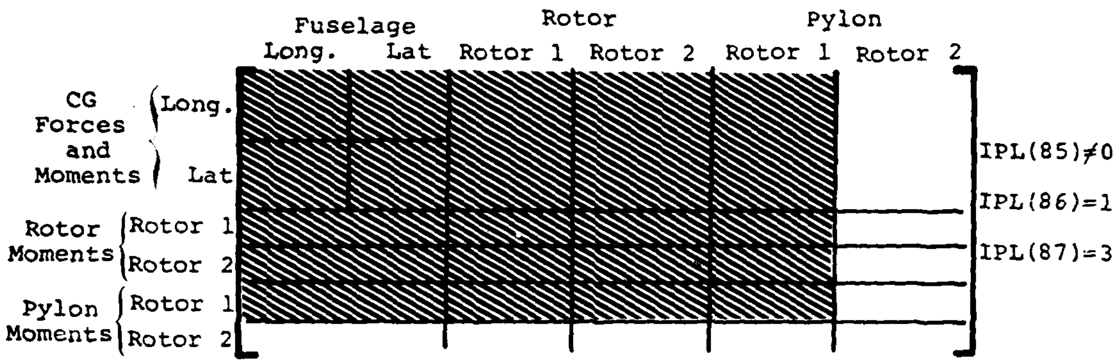


(e) Coupled Fuselage - Rotor 2

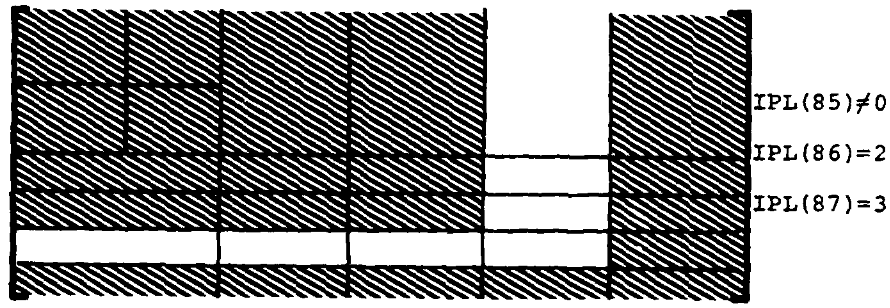


(f) Coupled Fuselage - Both Rotors

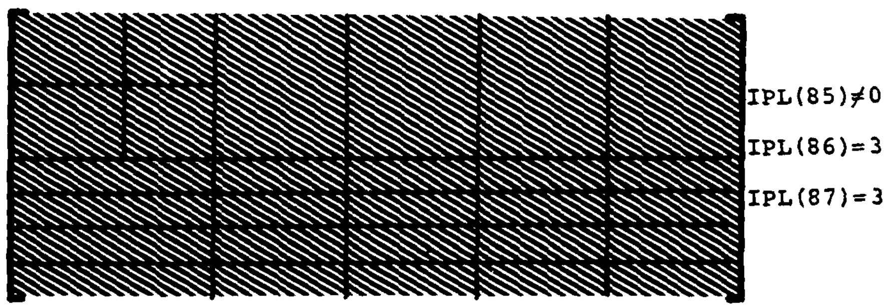
Figure 21. Continued.



(g) Coupled Fuselage - Both Rotors - Rotor 1 Pylon



(h) Coupled Fuselage - Both Rotors - Rotor 2 Pylon



(i) Coupled Fuselage - Both Rotors - Both Pylons

Figure 21. Concluded.

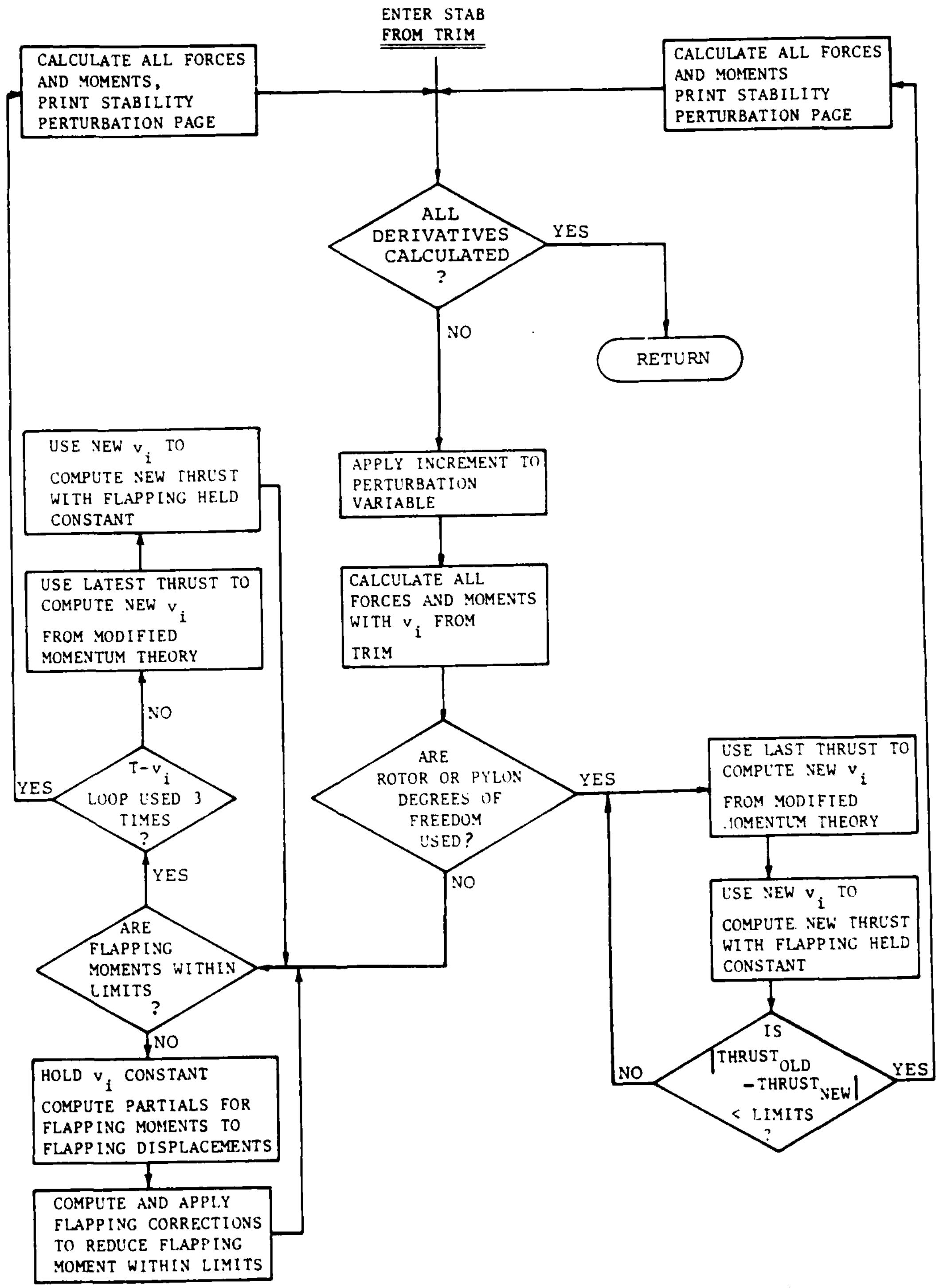


Figure 22. Logic Flow for STAB Partial Derivatives.

The form of the punched output is explained in Section 6.8.4.

IPL(90) should always be zero. It is intended for diagnostic use by the programmer only and is discussed in detail in Volume II.

IPL(92) is currently inactive.

Table 9 gives the value of IPL(93) required to print the numerators of the transfer functions computed by STAB.

The printing of the force and moment summary during the perturbation calculations in STAB can be suppressed by setting IPL(94) to a nonzero value.

TABLE 9. VALUES OF IPL(93) TO PRINT THE NUMERATORS OF THE TRANSFER FUNCTIONS.

Denominator of Transfer Function	Numerator of Transfer Function							
							M/R Flapping	
	u	w	θ	v	Φ	ψ	Long.	Lat
Collective	2	1	1	3	3	3	4,-1	4,-1
Long. Cyc	2	1	0,-1	3	3	3	4,-1	4,-1
Lat Cyc	3	3	3	2	0,-1	1	4,-1	4,-1
Pedal	3	3	3	2	1	0,-1	4,-1	4,-1

4.4 AIRFOIL DATA TABLE GROUP

The Airfoil Data Table Group does not have a group identification card of its own; i.e., no CARD 20. Rather, each data table included in the group has its own identification card.

The number of airfoil data table sets to be included is specified by IPL(2). IPL(2) may equal 0 through 10. A set of tables for an NACA 0012 airfoil section is compiled within the program and stored in the space allocated for the tenth table. If IPL(2) specifies that ten tables are to be read in, the tenth external table will overlay the internal 0012 data.

This internal 0012 table may be used any time nine or less airfoil data tables are read in, i.e., IPL(2) = 0 through 9. The 0012 table (if not overlaid) or any table that is input can be assigned to any one of the ten rotor airfoil aerodynamic subgroups or to the five aerodynamic surfaces by use of the 18th aerodynamic input, e.g., YRR(18,J), J = 1 through 10, YWG(18), YSTB1(18). Note, however, that data tables for the rotor must be airfoil section (two-dimensional) data, while tables for the aerodynamic surfaces must be surface (three-dimensional) data. See Sections 4.11.2 and 4.16.2 for further details on assigning data tables to the rotor and aerodynamic surfaces respectively.

The contents of each data table set are the same:

(1) Identification Card
(2) Title and Control Card
(3) Lift Coefficient Subtable (at least 3 cards)
(4) Drag Coefficient Subtable (at least 3 cards)
(5) Pitching Moment Coefficient Subtable (at least 3 cards)

The specific format for the first two cards of each set is identical, while the general format for each of the three subtables in any set is the same. Note that angle of attack is the only parameter which ever appears in the first seven-column field on any card in any table.

The Mach number entries in each subtable must start at zero and be in ascending order. Note that if the computed Mach number exceeds the highest Mach number in the subtable, the table lookup routine extrapolates the data to the computed Mach number.

The card set for the first angle of attack in each subtable must be for -180 degrees and the last for +180 degrees. Each card set for an angle of attack starts on a new card. In

between the card sets for these two angles, the card sets for other angles must be in increasing value of angle of attack. It is not necessary to have uniform increments between values of angle of attack or Mach number in a subtable or to have the same angles or Mach numbers in each subtable. It is assumed that the angle of attack entries in all airfoil data tables are the angles of attack of the chordline of the airfoil section or surface. This assumption should be remembered when developing the inputs for the control system rigging of cambered surfaces.

The minimum value for each of the six integer inputs on the control card (NXL through NZM) is 2. The maximum values of these inputs are defined by the maximum permissible number of entries in a table, i.e.,

Lift Subtable:	NXL*NZL + NXL + NZL $\leq$ 500
Drag Subtable:	NXD*NZD + NXD + NZD $\leq$ 1100
Pitching Moment Subtable:	NXM*NZM + NXM + NZM $\leq$ 575

For example, if the lift subtable is to have 10 Mach number entries (NZL = 10), then the number of angles of attack must be less than or equal to 44 (44 * 10 + 44 + 10 = 494). The minimum size table (2 by 2) is frequently used to enter a dummy pitching moment coefficient subtable (C_M = 0 at all Mach numbers). Such a subtable would require NXM = 2 and NZM = 2 on the Title and Control Card plus the following three cards for the subtable:

First Card:

Col	8-14	0.0 (lowest Mach number)
	15-21	1.5 (or any Mach number greater than the expected maximum)

Second Card:

Col	1-7	-180 (minimum angle of attack)
	8-14	0.0 (C_M at α = -180°, M = 0)
	15-21	0.0 (C_M at α = -180°, M = 1.5)

Third Card:

Col	1-7	180.0 (maximum angle of attack)
	8-14	0.0 (C_M at α = 180°, M = 0)
	15-21	0.0 (C_M at α = 180°, M = 1.5)

4.5 ROTOR 1 GROUP

This entire group must be omitted if IPL(3) = 1 or 3. This rotor always rotates counterclockwise when viewed from above, i.e., the standard direction of rotation for main rotors of American-made helicopters.

CARD 31

The number of blades, XMR(1), must be in the range from 2 to 7 inclusive. The geometric and physical properties of each blade and its attachment to the rotor hub are assumed to be identical to those of all other blades.

The rotor undersling, XMR(2), may be a nonzero quantity only for a teetering or gimbaled rotor. It is positive if the pitch-change axis is below the flapping axis. See Figure 23.

If the offset of the airfoil aerodynamic reference center from the pitch-change axis is constant, this single value may be input as XMR(3). In this case, the reference offset distribution on CARDS 3C, 3D, and 3E must be omitted. If XMR(3) $\geq$100., the distribution must be input. The offset distance is positive if the reference center is in front of the blade reference line.

The rotor radius, XMR(4), is measured from the centerline of rotor rotation to the blade tip.

If the chord is constant over the blade radius, this single value may be entered as XMR(5), and the chord distribution on CARDS 3F, 3G, and 3H must be omitted. If XMR(5) = 0, the chord distribution must be input.

If the blade twist is linear and less than 100 degrees from root to tip, the total twist may be input as XMR(6), and the program will compute the distribution. In this case, CARDS 3I, 3J, and 3K must be omitted. If XMR(6)$\geq$100, these twist distribution cards must be included. Positive twist is in the direction of positive blade pitch. The normal rotor blade with washout will have negative twist.

The flapping stop location, XMR(7), is the maximum amount the hub can flap without hitting the flapping stop spring. The normal input is positive. See also XMR(17), CARD 33.

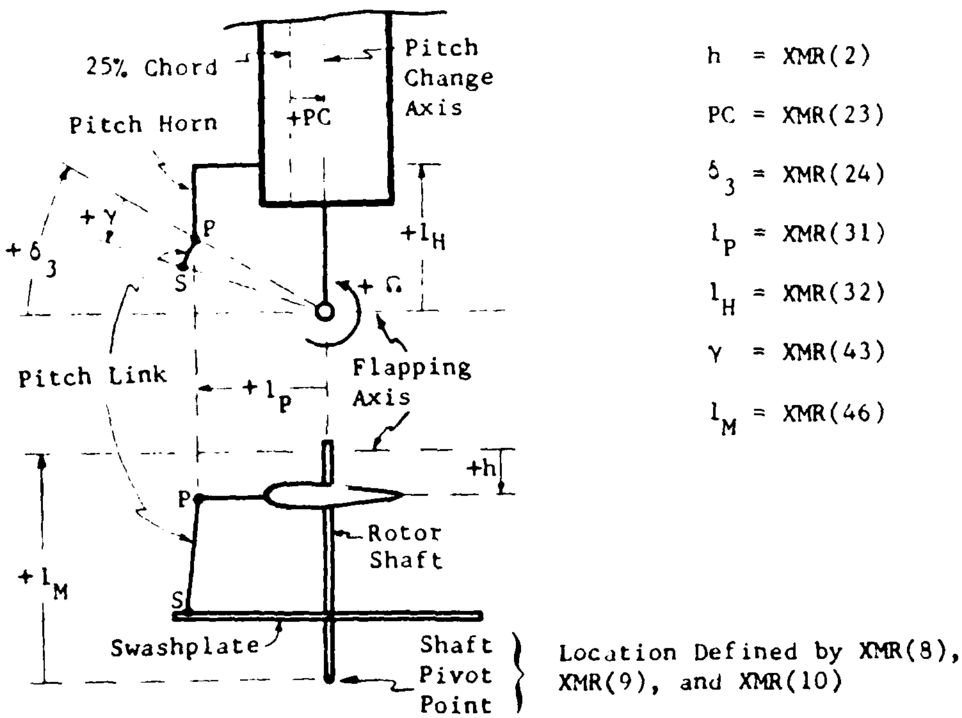


Figure 23. Definition of Pitch-Horn, Hub and Swashplate Geometry Inputs.

CARD 32

The location of the shaft pivot point as specified by XMR(8), (9), and (10) is primarily intended for use with tilt-rotor configurations. These inputs, in conjunction with the mast tilt angles and length (XMR(44), (45), and (46) on CARD 37) are used to determine the stationline, buttline, and waterline of the rotor hub, the point at which the summation of the rotor forces acts. For other than tilt-rotor aircraft, the shaft pivot point is normally located at the rotor hub, and the mast length, XMR(46), is set to 0.0.

Blade weight and inertia (XMR(11) and XMR(12), respectively) are only mandatory inputs when IPL(6) = 0 (i.e., when the main rotor elastic blade data set is not input). As used here the word blade includes the appropriate portion of the rotor hub as well as the blade itself for a teetering or gimbaled rotor. Blade weight is then the weight of a single blade/hub combination in pounds for a teetering or gimballed rotor. Blade inertia is the inertia of a single blade/hub combination about the line which passes through the blade feathering axis and the shaft. For an articulated rotor, XMR(11) and XMR(12) represent the mass and inertia of that portion of the rotor outboard of the flapping hinge, with the inertia calculated about the flapping axis. If the main rotor elastic blade data set is input (IPL(6) $\neq$ 0), the blade weight and inertia are internally computed from the blade weight distribution in the elastic blade data set, XMW(1) through XMW(21), and the values of XMR(11) and XMR(12) are ignored. All XMR(1) blades are assumed to be identical.

XMR(14), the pitch-lag coupling ratio, is positive for a nose-up angle with aft (positive) blade motion. (This input is used in conjunction with the lag angle input for each rotor mode shape.) The lag angle for the Ith mode is the product of XGMS(8,I) times the modal participation factor for that mode. The sum is taken for all the modes and multiplied by XMR(14) to get the change in blade pitch. Note that this input is not effective unless the rotor elastic data are input.

CARD 33

XMR(15) is the gear ratio between the swashplate and the blade root, i.e.,

(Blade pitch at root) = (nonretarded nonrotating swashplate angle)* XMR(15)

XMR(16), the hub-type indicator, is zero for a gimbaled or teetering rotor and nonzero for a hingeless or articulated rotor. The distinguishing characteristic of a gimbaled or teetering rotor is that the response of any blade depends on

the loading on all of the blades because of the moments transmitted across the rotor hub. On a rigid or articulated rotor, each blade acts independently, with the difference between these latter two being in the mode shape characteristics.

The flapping stop spring rate, XMR(17), is used in the dynamic model of the flapping stops. When flapping exceeds XMR(7), a restoring moment proportional to the displacement relative to the stop is applied.

The flapping spring rate per blade, XMR(18), generates a restoring moment whenever there is any flapping. See the description of the nonlinear flapping spring, on CARD 37, for further explanation.

In the explanation of XMR(17) and XMR(18), flapping is defined as the slope of the blade at the hub including displacements from all modes, but not including precone.

The reduced rotor frequency, XMR(19), is used only when the UNSAN unsteady aerodynamic option is activated for the rotor. Otherwise, the input is ignored. If the input is less than or equal to zero, it is reset to unity (1-per-rev). See the discussion of UNSAN in Volume I of Reference 1 to aid in determining this input.

The lead-lag damper, XMR(20), is used in conjunction with the lag angle input with the rotor mode shapes. The operation is similar to XMR(14) above except that the damper uses the modal velocities rather than the displacements.

If a blade segment is completely inboard of the hub extent, XMR(21), the segment produces no lift or pitching moment and has a drag coefficient of XMR(25) based on the planform area of the segment. If a blade segment is partially or completely outboard of the hub extent, the airfoil aerodynamics specified by IPL(46) on CARD 14 are used for the segment. If IPL(4) is less than 5, set XMR(21) = 0.0.

CARD 34

The location of the pitch-change axis, XMR(23), is the distance from the quarter (25 percent) chord of the blade to the blade feathering axis in units of chord lengths. Positive XMR(23) is toward the trailing edge of the blade. For example, if the pitch-change axis is 30-percent chord aft of the leading edge, XMR(23) should equal 0.05 (5 percent aft of the 25-percent chord line). Similarly, if the axis is at 17-percent chord, XMR(23) should equal -0.08 (8 percent forward of 25-percent chord line). A value of 0.0 (equivalent to 25-percent chord) is the normal input. This input is only used when one of the

unsteady aerodynamic options is activated (i.e., IPL(48) $\neq$ 0). See Figure 23.

The positive pitch-flap coupling angle, XMR(24), acts to reduce blade pitch with positive flapping. The tangent of the angle should be considered as having units of degrees of blade pitch change per degree of blade flapping. Also, see Section 4.5.1.

The drag coefficient for the hub, XMR(25), is discussed with hub extent on CARD 33.

The lead-lag spring rate, XMR(26), operates in conjunction with the lag angle input with the rotor mode shapes. It causes an inplane restoring moment in a manner exactly analogous to the operation of XMR(14) above.

If a Rotor-Induced Velocity Distribution Table is not input, the coefficient for tip vortex effect, XMR(27), can be used to modify the induced velocity distribution on the outboard 30 percent of the rotor blade to simulate the effect of shed tip vortices. The simulation gives improved airload calculations in the low-speed range by modeling the rotor as a wing with tip vortices and modifying the radial induced velocity distribution in the vicinity of the advancing and retreating blade tips (see Section 4.12.3). However, power and other performance values are not affected significantly. Rotor bending moments computed by another version of this program showed improved correlation with test data when a value of 10.0 was used for this coefficient. If the input is zero, the effect is removed.

CARD 35

The tip sweep angle, XMR(29), is the sweepback angle of the leading edge of the most outboard segment of the blade; it is also discussed in Section 4.11.2 as X(29).

The value of XMR(30) gives the tip-loss factor. If XMR(30) = 0, the tip-loss factor is computed internally (see Section 3.4 in Volume I of Reference 1). If IPL(4) is less than 5, set XMR(30) = 1.0.

If XMR(30) $\neq$ 0, then the lift is zero over that portion of the blade outboard of XMR(30)*XMR(4).

A geometric definition of XMR(31) and XMR(32) is given in Figure 23. The sign conventions are not a function of the type of pitch horn; hence, to define a trailing-edge pitch horn, simply input a negative length for l_p. See Section 8.1 in Volume I of Reference 1 for additional details.

The shaft axis component of the rotor average induced velocity is multiplied by XMR(33) and applied at the fuselage center of pressure, in the direction parallel to the rotor shaft, and is used in the calculation of the fuselage angle of attack.

XMR(35) is the Rotor 1 pitch-cone coupling ratio and is equal to the degrees of collective pitch for 1 degree of coning. The input is ignored if any mode shapes are input for Rotor 1 (i.e., IPL(6) $\neq$ 0).

CARD 36

The intended use of the rotor nacelle inputs on this card is to simulate changes in aerodynamic forces and in the cg location of a tilt-rotor aircraft during conversion. Each rotor has its own nacelle, although for a tilt-rotor aircraft all nacelle inputs are normally identical except that the buttlines of the aerodynamics centers, XMR(38) and XTR(38), are opposite in sign. For configurations other than tilt-rotor aircraft, the nacelle weight should be set to zero. However, even with zero nacelle weight, the nacelle drag inputs can still be used to simulate such effects as drag of a fairing around the mast, additional hub drag, etc.

Rotor nacelle weight, XMR(36), is the total weight of the nacelle, dynamic pylon, rotor hub, blades, etc., which contributes to a shift of the aircraft cg with longitudinal mast tilt angle. If the longitudinal mast tilt angle is to remain constant at the input value of XMR(44) during the run, and the aircraft cg input on CARD 121 is the aircraft cg for the input mast tilt angles of both rotors, then nacelle weight should be input as zero. Otherwise, a shift from the cg input on CARD 121 will be calculated as explained below.

Nacelle cg inputs, XMR(37-39), are intended to locate the cg of the moveable weight (pylon, rotor, etc.) for zero degrees longitudinal mast tilt and XMR(45) degrees lateral mast tilt. Since only the longitudinal tilt angle is variable during a maneuver and longitudinal tilt is in the body X-Z plane, only shifts in cg stationline and waterline are calculated. The shifts of cg station, ΔSTA, and waterline, ΔWL, due to longitudinal mast tilt angle, β_m, are given by the following equations:

$$\delta STA = Z\sin\beta_m + X(1 - \cos\beta_m)$$

$$\Delta\ WL = Z(1 - \cos\beta_m) - X\sin\beta_m$$

where

$$X = [XMR(36)/XFS(1)]*[XMR(8) - XMR(37)]$$

$$Z = [XMR(36)/XFS(1)]*[XMR(10) - XMR(39)]$$

The rotor nacelle differential flat plate drag area, XMR(40), is defined as the increase in the total flat plate drag of the aircraft (without rotors and at zero angles of attack and side-slip) as the longitudinal mast tilt angle is changed from 90 degrees (horizontal) to 0 degrees (vertical). Note that the nacelles for Rotors 1 and 2 are modeled separately; hence, this differential flat plate drag area is for one nacelle only. From XMR(40), the nacelle drag area, D_N, is computed by the following equation:

$$D_N = XMR(40)*\cos^3(\alpha_N)$$

where α_N is the angle between the free-stream velocity vector and its projection on the plane perpendicular to the rotor mast. This drag is then applied at the nacelle aerodynamic center which is assumed to be on the centerline of the mast at a distance XMR(41) feet from the mast pivot point. The direction for positive XMR(41) is defined as up the mast when the mast is vertical.

XMR(42) is the first mass-moment of the rotor about the flapping axis. If XMR(42) is input as zero for a quasi-static rotor, then the first mass moment is computed from the equation

$$\text{First Mass Moment} = \sqrt{XMR(11) * XMR(12)/32.19}$$

The actual value of the first mass moment should be input if at all possible; otherwise the moments acting on the blade due to centrifugal force and gravity may be calculated improperly.

CARD 37

The control phasing, XMR(43), is defined in Figure 23.

The rotor control system model is quite complex (see Section 8 of Reference 1). A simplified expression for blade feathering, θ, as a function of blade station, r, and blade azimuth, ψ, is given below:

$$\theta(r,\psi) = \theta_o + \theta_{TW}(r,\psi) - \beta(\psi)*\tan\delta_3 + \zeta(\psi)*\alpha_3$$

$$- \tan^{-1}\Big(\tan[B_1 + A_1*\tan(\delta_3 - \gamma)]\sin\psi$$

$$+ \tan[A_1 - B_1*\tan(\delta_3 - \gamma)]\cos\psi\Big)$$

where

θ = geometric pitch

θ_o = root collective pitch (computed from control positions)

θ_{TW} = change in blade pitch from root-to-blade segment due to built-in (XMR(6)) and elastic twist

β = blade flapping, based on out-of-plane displacement at r = first segment length

ζ = lag angle (based on XGMS inputs)

B_1 = longitudinal cyclic control input

A_1 = lateral cyclic control input

α_3 = pitch-lag coupling, XMR(14)

δ_3 = pitch-flap coupling, XMR(24)

γ = control phasing angle, XMR(43)

The longitudinal and lateral mast tilt angles, XMR(44) and XMR(45) respectively, are both zero for a mast which is vertical, i.e., parallel to the body Z-axis. For nonzero mast angles, the angles are treated as ordered rotations where the longitudinal mast tilt angle is the first rotation (positive forward) and the lateral mast tilt angle is the second rotation (positive to starboard). The mast length XMR(46) is the distance from the mast pivot point (XMR(8), (9), and (10) on CARD 32) to the rotor hub. The direction for positive XMR(46) is defined as up the mast when the mast is vertical. The mast length may be zero if the location of the hub is given by XMR(8), (9), and (10).

The nonlinear flapping spring is engaged whenever the absolute value of the hub flapping angle, β_H, is greater than XMR(47).

The order of the nonlinearity, r, is XMR(49) and need not be integer. The nonlinear spring rate, XMR(48), is based on this nonlinear order.

The equation for the flapping spring moment, M_B, is

$$M_B = XMR(18) * \beta_H, \qquad |\beta_H| \leq XMR(47)$$

$$M_B = M_o + \beta_H\left(XMR(18) + XMR(48) * |\beta_H|^{XMR(49)-1}\right),$$

$$|\beta_H| > XMR(47)$$

where

$$M_o = -XMR(48) * XMR(47) ** XMR(49)$$

CARD 38

XMR(50) is the break frequency of the filter used for the maneuver autopilot. The magnitude and time-lag functions for the filter are

$$H(if) = \frac{1}{\sqrt{1 + \left(\frac{f}{f_u}\right)^6}}$$

$$T_d(f) = \frac{\sum\limits_{m=0}^{2} \dfrac{\left(\frac{f}{f_u}\right)^{2m}}{\sin\left\{(2m+1)\frac{\pi}{6}\right\}}}{f_u\, 2\pi\left(1 + \left(\frac{f}{f_u}\right)^6\right)}$$

where

f = signal frequency, Hz

f_u = upper break frequency of filter, XMR(50)

It is suggested that the user try XMR(50) equal to rotor 1-per-rev, in Hertz. In that case, the magnitude and time lags are

Steady State: $|H(0)| = 1.0$

$$T_d(0) = \frac{0.31831}{f_u} \text{ seconds}$$

1-per-rev: $|H(if_u)| = 0.7071$

$$T_d(f_u) = \frac{0.3979}{f_u} \text{ seconds}$$

$$2\text{-per-rev:} \qquad |H(2if_u)| = 0.12403$$

$$T_d(2f_u) = \frac{0.0930}{f_u}$$

If the user wishes to choose a value of XMR(50) other than 1-per-rev, higher harmonic attenuation must be traded for steady state time lag.

XMR(55) and (56) are used to compute the increment to the pitch link load due to a feathering bearing with a nonzero torsional spring rate (such as an elastomeric bearing). The incremental pitch link load is

$$\Delta PLL = - (\theta_{grip} - XMR(56))* \frac{XMR(55)}{XMR(31)}$$

The geometric pitch angle, θ_{grip}, is the angle at the radius specified by XMR(32), so XMR(56), the pitch angle at which there is no pitching moment due to the feathering bearing, should be referenced to that radius also.

CARDs 39, 3A, and 3B (include these cards only if IPL(4) $<$ 0)

The radii to the outboard end of the blade segments are input on these cards if the segments are of unequal lengths. All three cards must be input regardless of the number of segments.

CARDs 3C, 3D, 3E

These three cards may be used to input a nonuniform chordwise offset of the airfoil aerodynamic reference centers from the pitch-change axis. The airfoil aerodynamic reference center is the point at which the aerodynamic forces and moments are defined to be acting for the equations or for the table being used for that segment. These cards must be omitted if XMR(3) <100 and must be included if XMR(3)≥ 100. The subscript of each entry in the XMACF array corresponds to the blade station number of the entry (e.g., XMACF(15) is at Blade Station No. 15).

CARDs 3F, 3G, 3H

These three cards may be used to input a nonuniform chord distribution for the blade. The cards must be omitted if XMR(5) $\neq$ 0 and must be included if XMR(5) = 0. The subscript of each entry in the XMC array corresponds to the blade station number of the entry; e.g., XMC(6) is the chord at Blade Station No. 6. The chord at Blade Station No. 0 is not input; it is assumed

to be equal to the chord at Blade Station No. 1. The distribution must be root to tip.

CARDs 3I, 3J, 3K

These three cards may be used to input a nonuniform twist distribution for the blade. The cards must be omitted if XMR(6) <100. The subscript of each entry in the XMT array corresponds to the blade station number of the entry; e.g., XMT(11) is the twist at Blade Station No. 11. The twist angle at Blade Station No. 0 is not input; it is defined to be zero and the twist distribution is then the set of angles of the chord line at the appropriate blade station with respect to the root collective pitch angle. Positive twist, like positive collective pitch, is defined as leading edge up. The distribution must be root to tip.

CARD 3L

This card must be read if IPL(14) = 1 or 3. The inputs on this card control a harmonic blade shaker located at blade station XMDI(4). The shaker applies a force to the blade along a line of action passing through the axis of computation and tilted XMDI(5) degrees back from the beamwise direction, positive up (for XMDI(5) = 0) if XMDI(1) is positive. The equation for the force depends on the value of XMDI(6);

XMDI(6) = 1.0, collective mode excitation

F = XMDI(1) * cos(XMDI(2)*Ω*t + XMDI(3))

where Ω is the main rotor rotational speed.

XMDI(6) = -1.0, cyclic mode excitation

F = XMDI(1) * cos(XMDI(2)*Ω*t + XMDI(3) + $\Delta W\psi_i$)

where $\Delta\psi_i = \psi_i - \psi_1$ (azimuth of i^{th} blade - azimuth of blade 1).

XMDI(6) = 0.0, scissor mode excitation

F = XMDI(1) * cos(XMDI(2)*Ω*t + XMDI(3) + $\frac{\text{XMR(1)}}{2}\Delta\psi_i$)

The force is applied to the first XMDI(7) blades.

CARD 3M

This card must be read if IPL(14) = 1 or 3. The inputs on this card control a harmonic control shaker which applies additional harmonics to all blades. For XMDI(12) = 1.0, a

collective control motion results,

$$\Delta\theta = XMDI(8) * \cos(XMDI(9)*\psi_1 + XMDI(10))$$

For XMDI(12) = 0.0, the harmonic excitation will have the same effect as moving the cyclic stick in a circular motion, giving a change in root geometric pitch for the i^{th} blade, $\Delta\theta_i$, of

$$\Delta\theta_i = XMDI(8) * \cos(XMDI(9)*\psi_1 + XMDI(10) - \psi_i)$$

A positive value for XMDI(9) yields an advancing stick stir, while a negative value gives a regressing stick stir.

For XMDI(12) = -1.0, the harmonic excitation will be equivalent to rocking the swashplate about a nonrotating axis which is XMDI(11) degrees from the lateral axis, measured in the direction opposite to that in which the rotor is turning. In this case, the change in geometric pitch for the i^{th} blade is

$$\Delta\theta_i = XMDI(8) * \cos(XMDI(9)*\psi_1 + XMDI(10)) * F$$

where

$$F = \sin(XMDI(11))*\cos(\psi_i) + \cos(XMDI(11))*\sin(\psi_i).$$

For XMDI(12) = 2.0, the control motion is applied in the rotating system. The change in geometric pitch for the i^{th} blade is

$$\Delta\theta_i = XMDI(8)*\cos(XMDI(9)*\psi_i + XMDI(10))$$

(Note that this expression is different than that for XMDI(12) = 1.0).

CARD 3N

The inputs on this card, XMDI(15) through XMDI(21), may be used in the same manner as the inputs on CARD 3M, XMDI(8) through XMDI(14). If the second control shaker is not needed in the analysis, set XMDI(15) = 0.0.

CARD 3O

The inputs on this card, XMDI(22) through XMDI(28), may be used in the same manner as the inputs on CARD 3U, XMDI(8) through XMDI(14). If the third control shaker is not needed in the analysis, set XMDI(22) = 0.0.

CARD 3P

This card may be used to input a nonuniform airfoil section distribution for the blade. The card must be omitted if IPL(46)$\geq$ 0 and must be included if IPL(46)<0. The format for the IDTABM array is 20I2 starting in column 1. These integer inputs correspond to the sequence number of the Rotor Airfoil Aerodynamic (RAA) Subgroup which is to be used at the specified blade station. The subscript of each entry in the IDTABM array specifies the blade station number of the entry. For example, if IDTABM(13) = 4, RAA Subgroup No. 4 is used at Blade Station No. 13. Each value of IDTABM must be less than or equal to IPL(11), the total number of RAA subgroups input. The airfoil section at Blade Station No. 0, the blade theoretical root, is not input; it is assumed to be part of the hub and capable of producing only drag based on the hub drag coefficient, XMR(25).

4.6 ROTOR 1 ELASTIC PYLON GROUP

The modal pylon inputs used in C81 can be generated by NASTRAN, or by some similar program, with or without the rotor mass included in the airframe eigenvalue solution. If the rotor mass was included in the NASTRAN model, it must have been represented as a point mass. All of the |IPL(9)| pylon modes for Rotor 1 must have been generated in the same manner, i.e., they all must have the effects of rotor mass, or none of them should. C81 properly accounts for the inclusion of the rotor mass (see Section 3.3 of Volume I of Reference 1).

The elastic pylon model for Rotor 1 only couples to Rotor 1 - there is no coupling to Rotor 2. Accelerations within the airframe are computed due to the response of the Rotor 1 elastic pylon.

CARD 41

The generalized inertia, XMP(1), natural frequency, XMP(2), and modal damping ratio, XMP(3), are all readily found as results of the airframe frequency analysis.

The swashplate coupling angle inputs, XMP(4), XMP(5), and XMP(6), are all multiplied by the pylon modal participation factor to give the swashplate coupling; i.e., when the participation factor is 1.0, the longitudinal cyclic coupling angle is XMP(4) radians.

CARD 42

The pylon mode shape displacement components are to be input in <u>body reference coordinates</u>, not <u>shaft reference coordinates</u>. This is only important if the rotor mast is tilted with respect to the body reference system.

XMP(8) and XMP(9) are the longitudinal and lateral linear displacements at the top of the mast. XMP(10) is the airframe vertical linear displacement at the top of the mast.

XMP(11) and XMP(12) are the body-reference pitch and roll angles of the top of the mast, i.e., they are the body-reference-system longitudinal and lateral angular displacements of the top of the mast. XMP(13) is the body-reference Z-axis torsional windup of the mast and pylon. Due to the generality of the mode shape inputs, one of the modes can represent the mast windup response, but the θ_x and θ_y components, XMP(11) and XMP(12), will be nonzero for this mode if there is any mast tilt.

CARDS 43, 44

Include these cards only if $|IPL(9)| \geq 2$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(15) through XMP(28) replacing XMP(1) through XMP(14).

CARDS 45, 46

Include these cards only if $|IPL(9)| \geq 3$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(29) through XMP(42) replacing XMP(1) through XMP(14).

CARDS 47, 48

Include these cards only if $|IPL(9)| \geq 4$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(43) through XMP(56) replacing XMP(1) through XMP(14).

CARDS 49, 4A

Include these cards only if $|IPL(9)| \geq 5$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(57) through XMP(70) replacing XMP(1) through XMP(14).

CARDS 4B, 4C

Include these cards only if $|IPL(9)| \geq 6$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(71) through XMP(84) replacing XMP(1) through XMP(14).

CARDS 4D, 4E

Include these cards only if $|IPL(9)| \geq 7$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(85) through XMP(98) replacing XMP(1) through XMP(14).

CARDS 4F, 4G

Include these cards only if $|IPL(9)| \geq 8$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(99) through XMP(112) replacing XMP(1) through XMP(14).

CARDS 4H, 4I

Include these cards only if $|IPL(9)| \geq 9$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(113) through XMP(126) replacing XMP(1) through XMP(14).

CARDS 4J, 4K

Include these cards only if $|IPL(9)| = 10$. The description for this pylon mode is identical to that of the first pylon mode, CARDS 41 and 42, with XMP(127) through XMP(140) replacing XMP(1) through XMP(14).

CARDS 4L through 4L + $|IPL(9)|$ must be input whenever IPL(9) $\neq 0$. The data on these cards are used to compute the accelerations at a given airframe location for each of the pylon modes. The data on CARD 4L define the location of the point and the data on the following cards give the linear and angular components of each pylon mode at that point.

The moment arms from the airframe center of mass to the specified point are defined as

$$X_p = (X_{cg} - XFSMS(1,1)) \quad \text{(positive forward)}$$

$$Y_p = -(Y_{cg} - XFSMS(2,1)) \quad \text{(positive to starboard)}$$

$$Z_p = (Z_{cg} - XFSMS(3,1)) \quad \text{(positive down)}$$

Given the linear and angular accelerations of the center of mass, $(\ddot{X}_{cg}, \ddot{Y}_{cg}, \ddot{Z}_{cg}, \ddot{\theta}_x, \ddot{\theta}_y, \ddot{\theta}_x)$, the linear accelerations at the specified point are

$$\ddot{X}_p = \ddot{X}_{cg} + \sum_n \ddot{q}_n \, \delta x_n + Z_p \ddot{\theta}_y - Y_p \ddot{\theta}_z$$

$$\ddot{Y}_p = \ddot{Y}_{cg} + \sum_n \ddot{q}_n \, \delta y_n + X_p \ddot{\theta}_z - Z_p \ddot{\theta}_x$$

$$\ddot{Z}_p = \ddot{Z}_{cg} + \sum_n \ddot{q}_n \, \delta z_n - X_p \ddot{\theta}_y - Y_p \ddot{\theta}_x$$

$$\ddot{\theta}_{x_p} = \ddot{\theta}_{x_{cg}} + \sum \ddot{q}_n \, \delta\theta_{x_n}$$

$$\ddot{\theta}_{y_p} = \ddot{\theta}_{y_{cg}} + \sum_n \ddot{q}_n \, \delta\theta_{y_n}$$

$$\ddot{\theta}_{z_p} = \ddot{\theta}_{z_{cg}} + \sum_n \ddot{q}_n \, \delta\theta_{z_n}$$

where

$\ddot{q}_n$ is the second derivative of the modal participation factor of the n^{th} pylon mode

δx_n is the x-component of the n^{th} pylon mode at the specified point

δy_n is the y-component

δz_n is the z-component

$\delta\theta_{x_n}$ is the roll component

$\delta\theta_{y_n}$ is the pitch component

$\delta\theta_{z_n}$ is the yaw component

The linear accelerations are output in g's. $\ddot{X}_p$ is positive forward, $\ddot{Y}_p$ is positive to starboard and $\ddot{Z}_p$ is positive down.

4.7 *ROTOR 1 ELASTIC BLADE DATA GROUP*

If IPL(6) = 0, this entire group must be omitted. The group consists of six distributions of rotor blade parameters: weight, beamwise mass moment of inertia, chordwise mass moment of inertia, beamwise center of gravity offset, chordwise center of gravity offset and the mode shapes. The first five distributions are input in three card sets, and all three cards are input for each of these sets regardless of the number of main rotor blade segments, |IPL(4)|. All six distributions are given from root to tip, and the segments in these distributions correspond to the segments used in the Rotor 1 Group. Therefore, if unequal segment length was used, the segments in the Rotor 1 Elastic Blade Data Group must have the same lengths as those described in the XMBS array. All blades of the rotor are assumed to have identical properties.

CARD 50

The first card of the data set is the identification card. If the Analytical Data Base option is available, the ID card can call a data set from the ADB and the remaining cards must be omitted. If the ADB is not used, the ID card must be followed by the six distributions.

CARDS 51/A1, 51/A2, 51/A3

The blade weight distribution inputs, XMW(1) - XMW(20), are defined to be the average values in pounds per inch across each of the blade segments. If less than 20 segments are used, then XMW(|IPL(4)| +1) through XMW(20) should be input as 0.0. The tip weight, XMW(21), is concentrated at the tip of the blade (r/R = 1.0).

CARDS 51/B1, 51/B2, 51/B3, 51/C1, 51/C2, 51/C3

The beamwise mass moments of inertia, XMW(22) - XMW(41), are about the chordline of the airfoil section, while the chordwise mass moments of inertia, XMW(43) - XMW(62), are about a line perpendicular to the chordline and located at the quarter chord of the segment. Normally, the chordwise inertias are much larger than the corresponding beamwise inertias. The units for both are in.-lb-sec^2/in. If less than 20 segments are used, then XMW(|IPL(4)| +22) through XMW(41) and XMW(|IPL(4)| +43) through XMW(62) should be input as 0.0. XMW(42) and XMW(63) are the mass moments of inertia of the tip weight about the beamwise and chordwise axes passing through the tip weight.

CARDS 51/D1, 51/D2, 51/D3, 51/E1, 51/E2, 51/E3

The average beamwise center-of-gravity offset, XMW(64) - XMW(84), and the average chordwise center-of-gravity offset, XMW(85) - XMW(105), are measured from the pitch change axis in the local beam-chord reference system. If less than 20 segments are used, then XMW(|IPL(4)|+64) through XMW(84) and XMW(|IPL(4)|+85) through XMW(104) should be input as 0.0. XMW(84) and XMW(105) are the center-of-gravity offsets of the tip weight, XMW(21).

CARD SETS 52/A1, 53/A1, ..., 5C/A1

These cards contain the coupled blade mode shapes. Exactly IPL(6) sets of mode shape data must be input, and IPL(6) + IPL(7) must be less than or equal to 12. Each mode shape (card set) consists of |IPL(4)|+5 cards. The first three cards contain 18 constants for that mode shape, six fields per card. The next |IPL(4)|+1 cards contain the modal displacement and bending moment coefficients at the blade stations. (Station 0 is the blade root while Station |IPL(4)| is the tip.) The last card contains information describing the change in the natural frequency of the mode with changes in RPM or root collective. If this last card is blank, the natural frequency remains constant at the value input on the first card of the set. As used here, pitch angle refers to the pitch angle at zero radius (this is the reference point for all blade pitch angles in C81). The set of data for Mode 1 (CARDS 52/A1 through 52/C1) is detailed in Section 2.7.6.1. The sets of data for additional modes use the same input sequence and format as Mode 1, so only the inputs for Mode 1 will be described here.

If the mode shapes were generated by Program DNAM05 (see Section 10), all the inputs to AGAP80 were punched in the proper format.

CARD 52/A1

The mode type indicator, XGMS(1,1), is used for gimbaled or teetering rotors to characterize the moment transfer across the rotor hub. See Volume I of Reference 1 for a discussion of the four mode types.

Input Value	Mode Type
-2	Independent
-1	Cyclic
0	Scissor
1	Collective

An independent mode responds to all forcing frequencies. The independent mode type is intended to be used for torsional modes primarily. For an articulated or hingeless rotor, XMR(16)≠0, the mode type indicator is reset to -2 regardless of the value input (i.e., all modes are defined to be independent modes).

The natural frequency, XGMS(2,1), is input as the ratio of the modal natural frequency to the rotor rotational frequency, i.e., XGMS(2,1) equals the natural frequency in cycles per minute divided by the RPM, XGMS(9,1).

The generalized inertia, XGMS(3,1), is the inertia for the equation for this mode, and is computed as part of the mode shape calculations.

The modal damping ratio, XGMS(4,1), is the ratio of the damping to the critical damping. Good data for this input are difficult to find, but the range is generally accepted to be around 0.005 to 0.02, except for modes which have a large amount of torsional response. In this case, the control system damping, which is also difficult to determine, should be included in XGMS(4,1). The control system damping is already included in the value punched by DNAM05. A value between 0.05 and 0.10 has been found to give good results.

The inplane and out-of-plane hub shear coefficients, XGMS (5,1) and XGMS(6,1), when multiplied by the modal participation factor, give the shears at the center of rotation in the shaft reference coordinate system.

CARD 52/A2

The pitch-link load coefficient, XGMS(7,1), gives the pitch-link load when multiplied by the modal participation factor.

The lag angle, XGMS(8,1), is the angle about the actual inplane hinge when the modal participation factor is 1.0. This input is valid only for an articulated rotor.

The reference RPM and reference root collective, XGMS(9,1) and XGMS(10,1), are the values at which the mode shape was generated. XGMS(10,1) is measured at the center of rotation.

The out-of-plane and inplane slopes of the pitch-change axis, relative to the undeformed position, are equal to XGMS(11,1) and XGMS(12,1) multiplied by the modal participation factor.

CARD 52/A3

For the discussion of the inputs on this card, let

OP(r) = the blade out-of-plane displacement component, as a function of r

IP(r) = the blade inplane displacement component, as a function of r

dm = the blade section infinitesimal mass

$$XGMS(13,1) = \int_0^R OP(r) \cdot r \cdot dm$$

$$XGMS(14,1) = \int_0^R OP(r) \cdot dm$$

$$XGMS(15,1) = \int_0^R IP(r) \cdot r \cdot dm$$

$$XGMS(16,1) = \int_0^R IP(r) \cdot dm$$

The out-of-plane and inplane displacement of the pitch bearing, relative to its undeformed position, for this mode is computed by multiplying XGMS(17,1) and XGMS(18,1) by the modal participation factor.

CARD 52/B2

The modal displacements and bending moment coefficients at the blade stations are given on this card and on the subsequent (IPL(4)) cards. Each card has the same format, and the displacements and bending moment coefficients are measured in the rotor shaft coordinate system. The blade displacements and bending moments due to this mode are equal to these inputs when the modal participation factor equals 1.0. Note that these variables cannot be changed by NAMELIST.

CARD 52/C1

The input data on the last card of each mode, which changes the natural frequency as a function of blade pitch angle and rpm, is based on positive and negative increments of each variable about the reference values given on CARD 52/A2, XGMS(9,1)

and XGMS(10,1). The high and low values of pitch must be equidistant from the reference value. The same is true of the rpm.

CARDS 53/A1 through the last card in the set.

The inputs for each of the remaining IPL(6)-1 modes are made in the same way as those of the first mode.

NOTE: It is imperative that the first mode entered be the primary out-of-plane mode characterized by a natural frequency close to 1-per-rev. This is necessary for the rotor elastic trim to work properly. Other than the first mode, the order in which the modes are entered is entirely a user option.

4.8 ROTOR 2 GROUP

The Rotor 1 and Rotor 2 models are identical except that Rotor 2 always rotates clockwise with respect to its mast as viewed from the top. Note that for zero mast tilt angles the Rotor 2 mast is vertical. The inputs required and the input sequence are identical for the two groups with the following exceptions:

(1) XTR(28), the sidewash coefficient, does not have a counterpart XMR(28) in the Rotor 1 Group.
(2) The effect of program logic inputs: IPL(1),(5),(7),(10),(47),(62),(76) and (78) affect Rotor 2 but not Rotor 1; different values of IPL(3),(12),(14),(48),(49),(73),(86),(87), and (88) are used for Rotor 2; IPL(4),(6),(9),(46),(61),(75), and (77) do not affect Rotor 2.

Hence, see the Rotor 1 Group for all except:

CARD 60

If IPL(1) = 11 or if IPL(3) = 2 or 3, omit the entire Rotor 2 group.

CARD 62

The blade weight and second mass moment of inertia inputs, XTR(11) and (12), are ignored if IPL(7) $\neq$ 0; i.e., when one or more Rotor 2 mode shapes are input.

CARD 63

If $|$IPL(5)$|$ is less than 5, set XTR(21) = 0.0.

CARD 64

The Rotor 2 sidewash coefficient, XTR(28), is used to simulate the effect of the fuselage on the wind vector at Rotor 2 as follows:

$$V_{R_2} = V_F \, (1. - XTR(28))$$

where V_F and V_{R_2} are the lateral components of the wind vector in body reference, felt by the fuselage and Rotor 2, respectively.

CARD 65

If $|IPL(5)|$ is less than 5, set XTR(30) = 1.0.

CARD 66

XTR(42), the first mass moment of inertia of Rotor 2, is ignored if IPL(7) $\neq$ 0.

CARD 67

For Rotor 2 to act as an antitorque rotor, the mast must be tilted from the vertical to its proper orientation, e.g., XTR(44) = 0.0 and XTR(45) = ±90. If XTR(45) = +90 (tilted to the right), the advancing blade is at the top of the rotor disc (clockwise rotation when viewed from the right side of the aircraft). If XTR(45) = -90 (tilted to the left), the advancing blade is at the bottom of the rotor disc (counter-clockwise rotation when viewed from the right side of the aircraft).

It should be noted that with XTR(45) = +90, the thrust vector for Rotor 2 is positive to starboard, so that an increase in Rotor 2 collective will increase the nose-to-port yawing moment (i.e., a negative yawing moment). Likewise, for XTR(45) = -90, an increase in Rotor 2 collective will cause an increase in nose-to-starboard (positive) yawing moment. For cambered airfoils, it may be necessary to input an inverted CLCD table for Rotor 2.

The Rotor 2 nonlinear flapping spring model is identical to that of Rotor 1.

CARD 68

The Rotor 2 filter frequency should be chosen with the same considerations as the Rotor 1 filter frequency. A value equal to Rotor 2 1-per-rev is recommended.

The Rotor 2 feathering bearing spring model is identical to that of Rotor 1.

CARDs 69, 6A, and 6B (Include only if IPL(5)<0)

The radius to the outboard end of the blade segments is input on these cards if the segments are unequal in length. All three cards must be input regardless of the number of segments.

CARDs 6C, 6D, and 6E

The nonuniform chordwise airfoil aerodynamic reference center distribution for Rotor 2 is input on these cards. Include

all three cards if $XTR(3) \geq 100.0$ and omit the cards if $XTR(3) < 100.0$.

CARDs 6F, 6G, 6H

The nonuniform chord distribution for Rotor 2 is input on these cards. All three cards must be included if $XTR(5) = 0.0$, and they must be omitted if $XTR(5) \neq 0.0$.

CARDs 6I, 6J, 6K

The nonuniform twist distribution for Rotor 2 is input on these cards. All three cards must be included if $XTR(6) \geq 100.0$, and they must be omitted if $XTR(6) < 100.0$.

CARDs 6L, 6M, 6N, 6O

These cards are to be read only if IPL(14) = 2 or 3. The Rotor 2 harmonic blade shaker and harmonic control motion models are identical to those of Rotor 1.

CARD 6P

The nonuniform airfoil section distribution is input on this card, which is included if $IPL(47) < 0$. The card must be omitted if $IPL(47) \geq 0$.

4.9 ROTOR 2 ELASTIC PYLON GROUP

The elastic pylon inputs for Rotor 2 are similar to those for Rotor 1, as described in Section 4.6. Since the mode shape components are expressed in the body-axis coordinate system, the Y component of the mode shape (XTP(9), for example) will be in a direction generally parallel to the shaft of an anti-torque rotor, and will be exactly aligned with it if the lateral mast tilt for Rotor 2 is ±90° and there is no longitudinal mast tilt.

Accelerations cannot be computed at points within the airframe due to the Rotor 2 pylon elastic response, so inputs similar to those on CARDs 4L and following are not required.

The Rotor 2 Elastic Pylon Group will contain, at most, 21 cards.

4.10 ROTOR 2 ELASTIC BLADE DATA GROUP

This group is included only if IPL(7) $\neq$ 0. The Rotor 2 elastic blade data is input in the same sequence and format as that of Rotor 1 (see Section 4.7), except for the Blade General Mode Shope Data, CARDS 82/A1, 82/A2, 82/A3, 83/A1, 83/A2, 83/A3, etc. The second subscript for the XGMS array is of a different form than for Rotor 1, because the Rotor 2 general mode shape data is stored immediately following the XGMS data for Rotor 1. This difference is only important in a NAMELIST procedure. Remember that IPL(6) + IPL(7) must be less than or equal to 12.

The same caveat about the first mode shape in the group, namely that it must be that out-of-plane mode whose frequency is nearest 1-per-rev, pertains to Rotor 2 also.

4.11 ROTOR AERODYNAMIC GROUP

This group is composed of not more than ten Rotor Airfoil Aerodynamic (RAA) subgroups, which are numbered sequentially on input. IPL(11) in the Program Logic Group specifies the number of subgroups to be input. If both rotor groups are deleted (IPL(3) = 3), it is not necessary to read any RAA subgroups (IPL(11) = 0); however, if IPL(3) ≠ 3, at least one subgroup is required and a zero input for IPL(11) will be reset to one.

Each subgroup consists of five cards that contain the YRR inputs. In the YRR(I,J) array, I is the sequence number of the inputs for one subgroup (I = 1 through 35) and J is the sequence number of the subgroup (J = 1 through 10). The data sequence for Subgroup No. 1 is given in Section 2.11. Inputs for other subgroups are in the identical sequence and format as for Subgroup No. 1. Each subgroup represents one airfoil section and is independent of all other RAA subgroups.

Normally, only one or two subgroups are needed: one for Rotor 1 and possibly a different one for Rotor 2. The additional subgroups are included so that blades which have a variable airfoil section along their span can be modeled. IPL(46) and (47) in the Program Logic Group control the option for variable airfoil sections along the blades for the main rotor and tail rotor respectively. If the option is activated, an airfoil section distribution for the appropriate rotor is read. This distribution specifies which RAA subgroup is to be used at Blade Stations No. 1 through No. 20. See the discussion of IPL(46) and (47) on CARD 14 and IDTABM(1-20) on CARD 30 for additional details.

In the following discussion, Y(I) refers to the Ith input of a subgroup, e.g., Y(18) is YRR(18,K), where K indicates the sequence number of the subgroup. In addition, X(J) refers to the Jth input of the Rotor 1 or Rotor 2 Group, e.g., X(29) is XMR(29) or XTR(29), depending on which rotor contains the blade segment of interest.

4.11.1 Aerodynamic Options

The inputs to the RAA subgroups are used by the CDCL subroutine to compute the steady state coefficients of airfoil section lift, drag, and pitching moment at Blade Stations No. 1 through No. 20 as functions of the local angle of attack, α, and Mach number, M. The program also includes two independent models

for computing the effects of yawed flow. Each model is associated with one of the two models for unsteady aerodynamics: BUNS and UNSAN. The BUNS yawed flow model is controlled by Y(28) and the UNSAN by Y(27).

Y(28) is the maximum value for the yawed flow angle in the BUNS model. The angle is in degrees, and an input of zero effectively deactivates the model. The value of this input does not affect Y(27).

Y(27) acts as a switch for the UNSAN model only and is interpreted as follows:

0 = off

1 = active for drag only

2 = active for lift only

3 = active for both

The program includes logic which prevents both yawed flow models being activated simultaneously when the unsteady aerodynamic options are off (IPL(48) = 0). When one of the unsteady options is on, the logic also assumes that only the yawed flow associated with the unsteady model activated by IPL(20) can be used. See Table 10.

TABLE 10. RELATIONSHIP OF UNSTEADY AND YAWED FLOW MODELS

Unsteady Model	Value of IPL(48)		Description of the Effect
BUNS	< 0	Y(27) reset to zero	UNSAN model turned off; BUNS model may be on or off
None	= 0	Y(28) reset to zero if Y(27) > 0	Either model may be used; BUNS model turned off if UNSAN model turned on
UNSAN	> 0	Y(28) reset to zero	BUNS model turned off; UNSAN model may be on or off

The BUNS and UNSAN unsteady aerodynamic models and the UNSAN yawed flow model are discussed in Section 3.4 of Volume I of Reference 1. Both unsteady models are similar in that each computes increments to the aerodynamic coefficients which are added to the steady state values. The following section describes how the CDCL subroutine computes the steady state coefficients using the BUNS yawed flow model.

4.11.2 Steady State Aerodynamic Coefficients

The steady state aerodynamic coefficients may be computed from equations which use the YRR inputs or interpolated from data tables. The control variable Y(18) specifies which method is to be used. The basic independent variables used by both the equations and the table lookup procedure are angle of attack and Mach number. A complete discussion of Y(18) is found at the end of this section. It is mentioned here primarily to caution the user that even though a table lookup procedure is used, many of the data for the equations must be entered as realistic values if either unsteady aerodynamic option is used. The variables that fall into this category are Y(1) through Y(11), Y(17), Y(20), Y(21), and Y(29) through Y(32).

The calculation of the steady state aerodynamic coefficients is the same at all blade stations with two exceptions. Near the blade root the computations are modified for hub extent as discussed in the Rotor 1 Group. The tip sweep angle input, X(29), is used to modify the radial and tangential velocity components impinging on the most outboard segment of the rotor blade. The sweep angle is the amount the leading edge is swept back with respect to the blade pitch-change axis. A more complete explanation of the tip sweep equations is given in Section 3.4 of Volume I of Reference 1.

The equations and logic checks used for all other blade segments are given below. The initial step is to determine the effective Mach number and angle of attack.

Let the local velocity components U_T, U_P and U_R be the tangential, perpendicular, and radial velocities, respectively. Then the yawed flow angle is

$$\Lambda = [\mathrm{Min}\,\{Y(28),\ \tan^{-1}(U_R/U_T)\,\}] * \mathrm{sign}[\tan^{-1}(U_R/U_T)]$$

and an effective Mach number is defined as

$$M = V/V_{sound} \quad [\cos Y(20)\ \Lambda]^{Y(21)}$$

where

$$V = [U_R{}^2 + U_T{}^2 + U_P{}^2]^{1/2}$$

and

V_{sound} = Speed of sound based on the values of XFC(26), (27), and (28).

This form of the Mach number expression is developed in Volume I of Reference 1. Suggested values for Y(20) and Y(21) are 0.2 and 1.0 (or 1.0 and 0.5) respectively, as discussed in Section 3.4 of Volume I of Reference 1.

The angle of attack of the blade segment, α, is defined by

$$\alpha = \theta + \alpha_o + \phi$$

and it is assumed that

$$-180° < \alpha \leq 180°$$

In the equation for α, θ is the local pitch, or feathering, of the chordline at the appropriate blade station. It is determined from control system geometry, blade geometry, and elastic blade deflections.

The term α_o is the angle between the chordline and the zero lift line of the segment. When equations are used to compute the aerodynamic coefficients,

$$\alpha_o = Y(29) + Y(30)*M + Y(31)*M^2 + Y(32)*M^3$$

When data tables are used, α_o is defined as zero since the data tables are assumed to be a function of chordline angle of attack. However, if the UNSAN unsteady aerodynamic option is activated (IPL(48)>0) and data tables are used, the values of Y(29) through Y(32) must be realistic inputs since they are used in the UNSAN analysis and are not computed from the tables.

The term ϕ is the local inflow angle, and is normally negative.

$$\phi = \tan^{-1}(U_P/U_T)$$

Hence, when equations are used, α is the angle of attack of the zero lift line and when data tables are used, it is the angle of attack of the airfoil section chordline.

For rotors with cambered airfoils where the chordline and zero lift line are not coincident, it is advisable to use data tables rather than equations to compute the aerodynamic coefficients. The mathematical model described by the equations was originally developed for symmetric airfoils exclusively. In most cases it is only marginally adequate for modeling the asymmetric stall characteristics about the zero lift line, the shift in zero lift line orientation in reversed flow, and the variations of coefficients with Mach number associated with cambered rotor airfoil sections. Hence, if the user wishes to model cambered airfoil sections with the equations, the flight conditions should be restricted to those where rotor stall is not significant and the reversed flow region is small; e.g., low blade loading coefficient (C_T/σ) and low advance ratio (μ).

A modified angle of attack is then computed from

$$\alpha_1 = \begin{cases} \alpha \cos\Lambda & \text{if } \alpha < 90° \\ \alpha & \text{if} |\alpha| > 90° \end{cases}$$

If Y(18) indicates that the table lookup procedure is to be used, the procedure is entered at this point with the above values of α_1 and M, and returns the interpolated values of the aerodynamic coefficients. The lift coefficient is then divided by $\cos\Lambda$ and all three coefficients are returned to the subroutine that called CDCL.

If Y(18) indicates that equations are to be used, the next step is to determine the lift curve slope of the airfoil at the current Mach number.

The input value of the Mach number at the lower boundary of the supersonic region, Y(2), is checked against a calculated value, M_{SC}, to determine the value of the lower boundary to be used, M_S.

$$M_S = \text{Max}\ \{Y(2),\ M_{SC}\}$$

The expression for M_{sc} is obtained by assuming that the slope of the lift curve at the critical Mach number, Y(1), is equal to the slope of the lift curve at M_{sc}.

The equation for the slope of the lift curve takes one of three forms, depending on whether the Mach number is subsonic, transonic, or supersonic.

$$a_1 = Y(8) + Y(9)M + Y(10)M^2 + Y(11)M^3 \qquad \text{(subsonic)}$$

$$a_2 = B_0 + B_1M + B_2M^2 \qquad \text{(transonic)}$$

$$a_3 = 4/(57.3\ \sqrt{M^2 - 1}) \qquad \text{(supersonic)}$$

Since the critical Mach number is subsonic, the slope of the lift curve at M = Y(1) is

$$(a_1)_{CR} = Y(8) + Y(9)*Y(1) + Y(10)*Y(1)^2 + Y(11)*Y(1)^3$$

If $M = M_{sc}$ in the equation for the supersonic lift curve slope, a_3, and $a_3 = (a_1)_{CR}$, then

$$M_{sc} = \sqrt{1 + (0.0698/(a_1)_{CR})^2}$$

Then the final selection for the slope of the lift curve, a, is made:

$$a = \begin{cases} a_1 \text{ if } M < Y(1) \\ a_2 \text{ if } Y(1) \leq M < M_s \\ a_3 \text{ if } M_s \leq M \end{cases}$$

The coefficients B_0, B_1, and B_2 in the equation for a_2 are computed internally by matching end points with a_1 and a_3 and the slope of a_3.

$$a_2 = a_1 \qquad \text{at } M = Y(1)$$

$$\left.\begin{aligned} a_2 &= a_3 \\ \frac{da_2}{dM} &= \frac{da_3}{dM} \end{aligned}\right\} \qquad \text{at } M = M_S$$

Next a test is made on α to see if the airfoil is in normal or reversed flow. Several intermediate variables in the calculation of lift coefficient are set according to the results. The angle of attack, α, is further resolved to be between plus and minus 90 degrees in either case.

If $|\alpha_1| \leq 90°$,

$$\alpha = |\alpha_1|$$

$$C_{L_O} = Y(3)$$

$$K_L = Y(4)M + Y(5)M^2 + Y(6)M^3$$

$$\alpha_B = |(C_{L_O} + K_L)/a| + 5°$$

If $|\alpha_1| > 90°$,

$$\alpha = 180° - |\alpha_1|$$

$$C_{L_O} = Y(7)$$

$$K_L = 0$$

$$\alpha_B = |C_{L_O}/a| + 5°$$

The C_L versus α curve has the form shown in Figure 24. At the point P_1 in Figure 24,

$$C_L = C_{L_O} + K_L$$

$$\alpha = C_L/a = \alpha_S$$

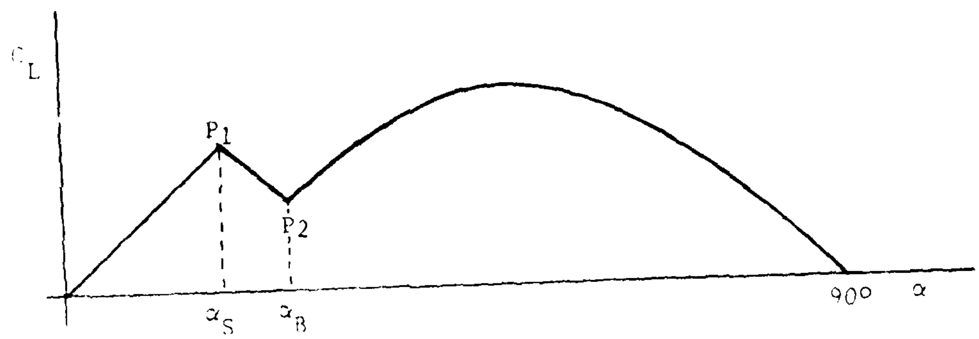


Figure 24. General Lift Coefficient Versus Angle of Attack Curve.

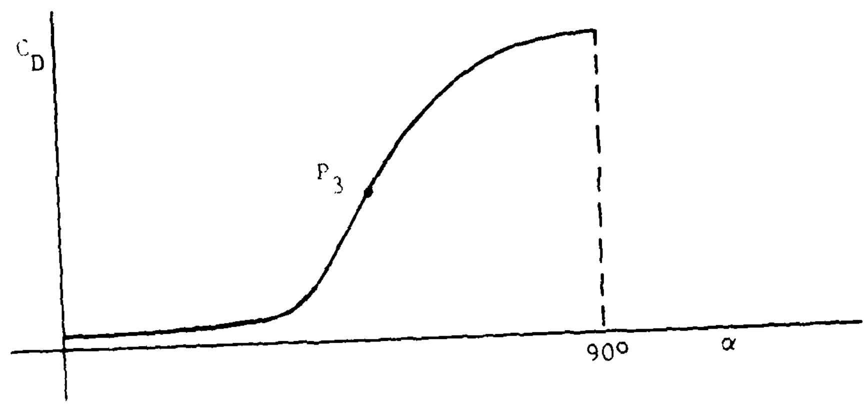


Figure 25. General Drag Coefficient Versus Angle of Attack Curve.

At P_2 in Figure 24,

$$\alpha = \alpha_B$$

Linear interpolation is used to evaluate C_L for points between P_1 and P_2.

For $\alpha_B \le \alpha \le 90°$,

$$C_L = [\{1.876 \sin \alpha - (.581)\} K + 0.81] \cos \alpha$$

where

$$K = \begin{cases} 1 + 0.25M^4 & \text{if } M \le 1 \\ 0.85 + 0.82/[M-0.8] & \text{if } M > 1 \end{cases}$$

The form of the C_D versus α curve is shown in Figure 25. At the point P_3 in Figure 25, $\alpha = \alpha_X$ and $C_D = C_{D_X}$, where either $\alpha_X = \alpha_s$ and $C_{D_X} < Y(16)$, or $\alpha_X < \alpha_s$ and $C_{D_X} = Y(16)$.

For $M<Y(2)$, i.e., below the supersonic region, the drag coefficient expression used depends on the value of α.

For $0 \le \alpha \le \alpha_X$,

$$C_D = \text{Min} \left\{ \begin{array}{l} Y(16),\ (Y(12) + Y(13)\alpha + Y(14)\alpha^2 \\ \\ + \text{Max}\,\{0,\ Y(19)\alpha - Y(1) + \text{Max}[M,\ 0.35]\}) \end{array} \right\}$$

NOTE: In this drag equation, α is the angle of attack with respect to the airfoil section zero lift line. Hence, for cambered airfoil sections where chordline and zero lift line are not coincident, care should be taken that the coefficients Y(12), (13), and (14) are referenced to the zero lift line rather than to the chordline.

If the drag rise coefficient, Y(19), is input as zero, it is reset to 0.0332 per degree.

For $\alpha_X \leq \alpha \leq 90°$ or $C_D \leq C_{D_X}$,

$$C_D = K_4 \sin^2 \alpha + (C_{D_X} - K_4 \sin^2 \alpha_X) \cos \alpha / \cos \alpha_X$$

where $K_4 = 2.1$ K.

In the supersonic region, $M \geq M_s$

$$C_D = \text{Min} \quad Y(16), \quad Y(12) + 4[(\alpha/57.3)^2 + Y(15)]/\sqrt{M^2 - 1}$$

The calculation of steady state pitching moment coefficients is best understood by following the logic flow chart in Figure 26, which is repeated from Volume I of Reference 1. The procedure was developed in order to curve fit C_M versus α curves at various Mach numbers such as those sketched in Figure 27. The symbols used in the flow chart are defined in terms of the inputs below. Reasonable values of the inputs for an NACA 0012 airfoil section are listed in brackets.

A_1 = Y(22)	[-.002488]
A_2 = Y(23)	[-.009456]
A_3 = Y(24)	[.82]
A_4 = Y(25)	[0.0]

The inputs Y(22), Y(23), and Y(24) are coefficients for a quadratic function of α determining the corresponding value of Mach number at which the C_M curve breaks sharply away from the input constant value, Y(25).

For $\alpha < 90°$, the first series of calculations and tests is to determine the relative sizes of α, the angle of attack, α_B, corresponding to $M_{eff} = M$ on the "break" curve mentioned previously, and of A_5, the critical value of α defined by the "break" curve for M = 0. The evaluation of C_M is different for $0 \leq |\alpha| \leq \alpha_B$, $\alpha_B < |\alpha| \leq A_5$, and for $A_5 < |\alpha| < 90°$.

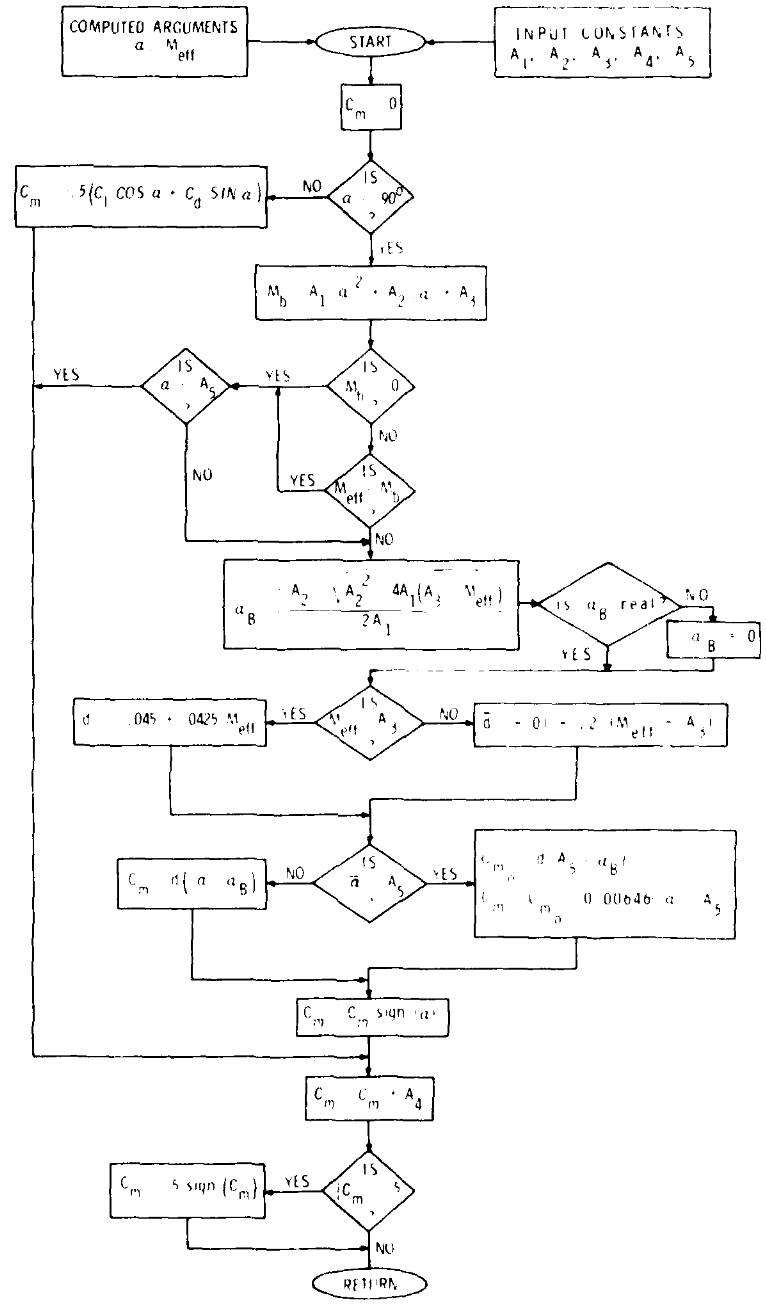


Figure 26. Flow Chart for Steady-State Pitching Moment Calculation.

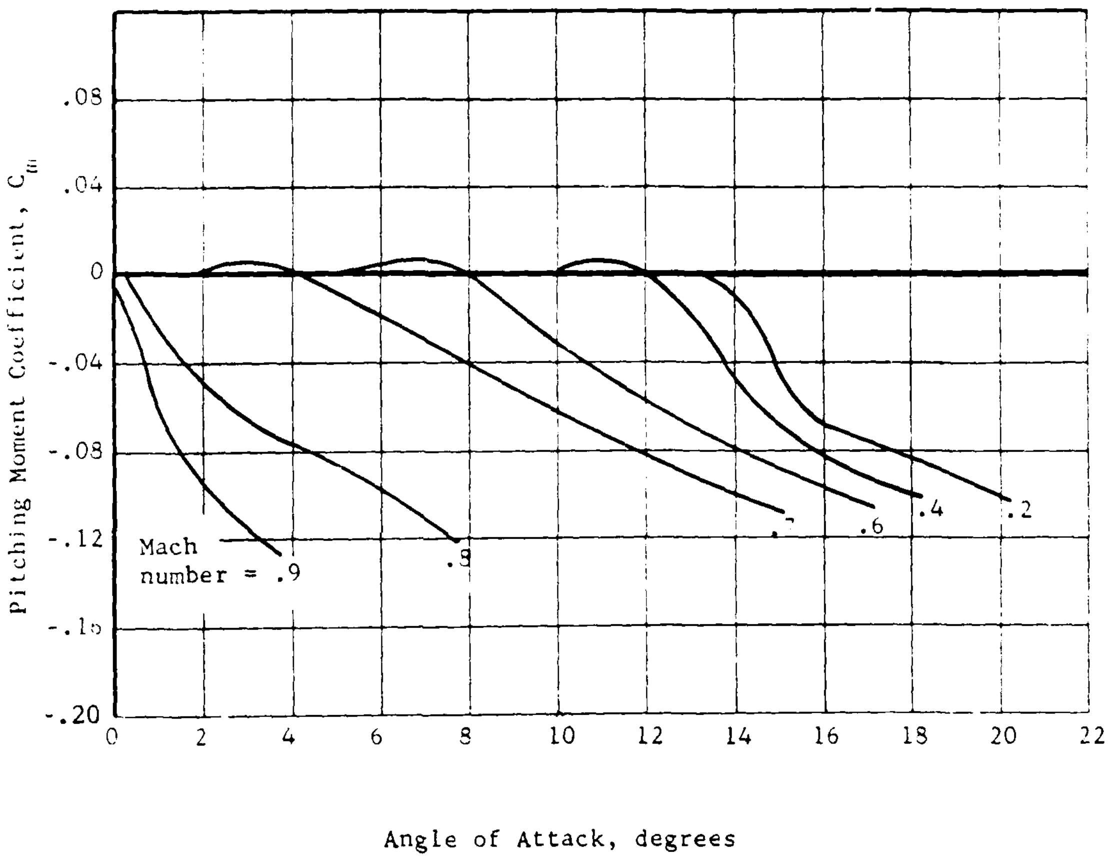


Figure 27. Typical Curves of Pitching Moment Coefficient Versus Angle of Attack at Various Mach Numbers.

For $|\alpha|$ less than α_B,

$$C_M = Y(25)$$

For $|\alpha|$ between α_B and A_5, a slope, $\bar{d}$, is computed for the C_M line between α_B and A_5. This slope depends on M_{eff} and an input critical value, Y(24), which is the point on the "break" curve for $\alpha = 0$. The pitching moment coefficient is calculated from

$$C_M = (|\alpha| - \alpha_B)\bar{d} \text{ sign}(\alpha) + Y(25)$$

If $|\alpha|$ is greater than A_5, a second slope included in the program is used.

$$C_M = (A_5 - \alpha_B)\bar{d} - 0.00646 (|\alpha| - A_5) \text{ sign } (\alpha) + Y(25)$$

For $|\alpha| > 90°$, the aerodynamic center is assumed to be located at the 0.75 chord rather than at the 0.25 chord. The pitching moment about the blade neutral axis (assumed to be at the 0.25 chord) is in this case mainly due to lift and drag forces. Hence,

$$C_M = -0.5(C_L \cos \alpha + C_D \sin \alpha) + Y(25)$$

As shown in the flow diagram (Figure 26), the absolute value of C_M is limited not to exceed 0.5 in all cases.

Y(33), Y(34), and Y(35) are increments which are added to the steady state value of the lift, drag, and pitching moment coefficients, respectively. Each increment is added to its corresponding coefficient, whether the coefficient is computed from equations or obtained from a data table. However, the most common use of these increments is with data tables. For example, if all drag coefficients in a table appear uniformly too high or too low, Y(34) can be used to change the drag at all combinations of angle of attack and Mach number witnout having to repunch the entire drag table. Similarly, Y(33) can be used to cause an effective shift in the zero lift line orientation.

NOTE: The control variable for the use of C_L, C_D, and C_M tables, Y(18), operates as follows:

(1) If Y(18) = 0, the aerodynamic coefficients are computed from the above equations using the YRR inputs.

(2) If Y(18) > 0, the Y(18)th Airfoil Data Table included in the Data Table Group will be used to compute the steady state aerodynamic coefficients. Note that a set of data tables for the NACA 0012 airfoil is stored permanently in Airfoil Data Table No. 10. (This table is stored internally as Airfoil Data Table No. 2 in the small core-storage version of the program.) These tables are shown in Figure 28. See the Data Table Group for additional details.

VERT-SIK 0012 + CM CLCD DATA TABLES USED

CL

ALPHA/MACH	0.0	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.90000	1.00000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-172.00000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000
-161.00000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000
-147.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-129.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-49.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-39.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-21.00000	-0.80000	-0.80000	-0.81000	-0.83000	-0.85000	-0.85000	-0.85000	-0.71000	-0.68000	-0.64000	-0.64000
-16.50000	-1.00700	-1.00700	-0.94400	-0.96000	-0.95500	-0.96500	-0.96500	-0.79500	-0.76000	-0.70000	-0.70000
-15.00000	-1.19000	-1.19000	-1.09000	-1.05500	-0.99000	-0.98000	-0.98000	-0.83000	-0.77000	-0.72000	-0.72000
-14.00000	-1.33300	-1.33300	-1.22000	-1.09600	-1.00000	-0.97000	-0.97000	-0.84000	-0.80500	-0.73000	-0.73000
-13.00000	-1.33400	-1.33400	-1.24000	-1.12000	-1.00000	-0.96000	-0.96000	-0.85000	-0.81500	-0.73500	-0.73500
-12.00000	-1.25500	-1.25500	-1.26000	-1.13000	-1.00000	-0.94700	-0.94000	-0.85000	-0.82000	-0.74000	-0.74000
-11.00000	-1.16100	-1.16100	-1.19000	-1.12000	-0.99400	-0.93000	-0.92300	-0.85000	-0.81000	-0.74000	-0.74000
-10.00000	-1.05500	-1.05500	-1.10000	-1.08200	-0.98500	-0.91000	-0.90000	-0.84500	-0.80500	-0.73000	-0.73000
-8.00000	-0.84400	-0.84400	-0.88000	-0.90700	-0.92200	-0.87000	-0.84000	-0.82000	-0.77000	-0.69500	-0.69500
-6.00000	-0.63300	-0.63300	-0.66000	-0.68400	-0.74100	-0.77000	-0.75000	-0.77000	-0.72000	-0.59300	-0.59300
-4.00000	-0.42200	-0.42200	-0.44000	-0.45600	-0.49400	-0.54400	-0.57800	-0.62700	-0.60300	-0.39600	-0.39600
-2.00000	-0.21100	-0.21100	-0.22000	-0.22800	-0.24700	-0.27200	-0.31300	-0.35000	-0.39500	-0.20000	-0.20000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00000	0.21100	0.21100	0.22000	0.22800	0.24700	0.27200	0.31300	0.35000	0.39500	0.20000	0.20000
4.00000	0.42200	0.42200	0.44000	0.45600	0.49400	0.54400	0.57800	0.62700	0.60300	0.39600	0.39600
6.00000	0.63300	0.63300	0.66000	0.68400	0.74100	0.77000	0.75000	0.77000	0.72000	0.59300	0.59300
8.00000	0.84400	0.84400	0.88000	0.90700	0.92200	0.87000	0.84000	0.82000	0.77000	0.69500	0.69500
10.00000	1.05500	1.05500	1.10000	1.08200	0.98500	0.91000	0.90000	0.84500	0.80500	0.73000	0.73000
11.00000	1.16100	1.16100	1.19000	1.12000	0.99400	0.93000	0.92300	0.85000	0.81000	0.74000	0.74000
12.00000	1.25500	1.25500	1.26000	1.13000	1.00000	0.94700	0.94000	0.85000	0.82000	0.74000	0.74000
13.00000	1.33400	1.33400	1.24000	1.12000	1.00000	0.96000	0.96000	0.85000	0.81500	0.73500	0.73500
14.00000	1.33300	1.33300	1.22000	1.09600	1.00000	0.97000	0.97000	0.84000	0.80500	0.73000	0.73000
15.00000	1.19000	1.19000	1.09000	1.05500	0.99000	0.98000	0.98000	0.83000	0.79000	0.72000	0.72000
16.50000	1.00700	1.00700	0.94400	0.96000	0.96500	0.96500	0.96500	0.79500	0.76000	0.70000	0.70000
21.00000	0.80000	0.80000	0.81000	0.83000	0.85000	0.85000	0.85000	0.71000	0.68000	0.64000	0.64000
39.00000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000
49.00000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000
129.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
147.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
161.00000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000
172.50000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 28. Set of Data Tables for the NACA 0012 Airfoil Section.

VERT-SIK 2012 + CM CLCD DATA TABLES USF.

CD

ALPHA/MACH	0.0	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.7500	0.80000	0.90000	1.00000
-180.00000	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200
-175.00000	0.05200	0.06200	0.05200	0.06200	0.06200	0.06200	0.06200	0.05200	0.06200	0.06200	0.06200
-170.00000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
-155.00000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
-150.00000	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
-140.00000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
-120.00000	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
-110.00000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
-100.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
-90.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
-80.00000	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
-70.00000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
-60.00000	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
-50.00000	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
-30.00000	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200
-21.00000	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200
-16.00000	0.15500	0.15500	0.18100	0.20700	0.23500	0.25700	0.27400	0.29200	0.30500	0.34200	0.34200
-15.00000	0.10200	0.10200	0.14800	0.18100	0.20900	0.23300	0.25200	0.27100	0.28200	0.29800	0.29800
-14.00000	0.03400	0.03400	0.09900	0.14600	0.18000	0.21200	0.23300	0.24900	0.26000	0.29300	0.29300
-13.00000	0.02640	0.02640	0.04550	0.09400	0.14800	0.19100	0.21600	0.23100	0.23900	0.27200	0.29200
-12.00000	0.02200	0.02200	0.03300	0.06000	0.11100	0.16400	0.19800	0.21100	0.22000	0.25200	0.29100
-11.00000	0.01960	0.01960	0.02320	0.03800	0.07800	0.13500	0.17000	0.19200	0.20200	0.23200	0.27500
-10.00000	0.01740	0.01740	0.01890	0.02590	0.05300	0.10500	0.14500	0.17600	0.18600	0.21300	0.25400
-9.00000	0.01540	0.01540	0.01590	0.01870	0.03510	0.07700	0.12200	0.15900	0.17200	0.19900	0.23200
-8.00000	0.01380	0.01380	0.01380	0.01470	0.02200	0.05300	0.10100	0.14000	0.15500	0.18300	0.21400
-7.00000	0.01220	0.01220	0.01220	0.01230	0.01410	0.03500	0.08200	0.11100	0.13900	0.16900	0.19200
-6.00000	0.01100	0.01100	0.01100	0.01100	0.01100	0.02120	0.06150	0.08200	0.12000	0.14000	0.17000
-5.00000	0.01000	0.01000	0.01000	0.01000	0.01000	0.01320	0.03800	0.05400	0.08800	0.11100	0.14000
-4.00000	0.00930	0.00930	0.00930	0.00930	0.00930	0.01000	0.01670	0.03000	0.05750	0.09500	0.11200
-3.00000	0.00880	0.00880	0.00880	0.00880	0.00880	0.00900	0.01020	0.01750	0.03550	0.08600	0.10200
-2.00000	0.00850	0.00850	0.00850	0.00850	0.00850	0.00850	0.00860	0.01170	0.02400	0.08100	0.09800
-1.00000	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00910	0.01750	0.07800	0.09600
0.0	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.00800	0.01170	0.07800	0.09500
1.00000	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00830	0.00910	0.01750	0.07800	0.09600
2.00000	0.00850	0.00850	0.00850	0.00850	0.00850	0.00850	0.00860	0.01170	0.02400	0.08100	0.09900
3.00000	0.00880	0.00880	0.00880	0.00880	0.00880	0.00900	0.01020	0.01750	0.03550	0.08600	0.10200
4.00000	0.00930	0.00930	0.00930	0.00930	0.00930	0.01000	0.01670	0.03000	0.05750	0.09500	0.11200
5.00000	0.01000	0.01000	0.01000	0.01000	0.01000	0.01320	0.03800	0.05400	0.08800	0.11100	0.14000
6.00000	0.01100	0.01100	0.01100	0.01100	0.01100	0.02120	0.06150	0.08200	0.12000	0.14000	0.17000
7.00000	0.01220	0.01220	0.01220	0.01230	0.01410	0.03500	0.08200	0.11100	0.13900	0.16900	0.19200
8.00000	0.01380	0.01380	0.01380	0.01470	0.02200	0.05300	0.10100	0.14000	0.15500	0.18300	0.21400
9.00000	0.01540	0.01540	0.01590	0.01870	0.03510	0.07700	0.12200	0.15900	0.17200	0.19900	0.23200
10.00000	0.01740	0.01740	0.01890	0.02590	0.05300	0.10500	0.14500	0.17600	0.18600	0.21300	0.25400
11.00000	0.01960	0.01960	0.02320	0.03800	0.07800	0.13500	0.17000	0.19200	0.20200	0.23200	0.27500
12.00000	0.02200	0.02200	0.03300	0.06000	0.11100	0.16400	0.19800	0.21100	0.22000	0.25200	0.29100
13.00000	0.02640	0.02640	0.04550	0.09400	0.14800	0.19100	0.21600	0.23100	0.23900	0.27200	0.29200
14.00000	0.03400	0.03400	0.09900	0.14600	0.18000	0.21200	0.23300	0.24900	0.26000	0.29300	0.29300
15.00000	0.10200	0.10200	0.14800	0.18100	0.20900	0.23300	0.25200	0.27100	0.28200	0.29800	0.29800
16.00000	0.15500	0.15500	0.18100	0.20700	0.23500	0.25700	0.27400	0.29200	0.30500	0.34200	0.34200
21.00000	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200	0.33200
30.00000	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200	0.56200
50.00000	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
60.00000	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
70.00000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
80.00000	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
90.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
100.00000	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200	2.02200
110.00000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
120.00000	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
140.00000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
150.00000	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
155.00000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
170.00000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
175.00000	0.05200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200
180.00000	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200

Figure 28. Continued.

VERT-SIK 0012 + CM CL CD DATA TABLES USED

CM

ALPHA/MACH	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.90000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-170.00000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000
-165.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-160.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-135.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-90.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-30.00000	0.17400	0.18400	0.19600	0.21400	0.23500	0.25000	0.26400	0.27700	0.29800
-23.00000	0.11200	0.11800	0.12800	0.14400	0.15700	0.17100	0.18300	0.20600	0.23200
-16.00000	0.07300	0.07800	0.08600	0.09700	0.10800	0.11700	0.13700	0.17600	0.20000
-15.00000	0.05400	0.06500	0.07300	0.08400	0.09700	0.11100	0.13300	0.17300	0.19500
-14.00000	0.0	0.02700	0.05400	0.06800	0.08600	0.10300	0.12700	0.16700	0.18900
-13.00000	0.0	-0.00150	0.02500	0.05000	0.07400	0.09300	0.12200	0.16300	0.18400
-12.00000	0.0	0.0	0.00200	0.03000	0.06000	0.08300	0.11600	0.15700	0.17600
-11.00000	0.0	0.0	-0.00300	0.01400	0.04600	0.07400	0.10800	0.14900	0.17000
-10.00000	0.0	0.0	-0.00150	0.00200	0.03200	0.06500	0.10000	0.14200	0.16300
-9.00000	0.0	0.0	0.0	-0.00300	0.01600	0.05400	0.08900	0.13200	0.15400
-8.00000	0.0	0.0	0.0	-0.00400	0.00500	0.04100	0.08200	0.12300	0.14500
-7.00000	0.0	0.0	0.0	0.0	-0.00400	0.02750	0.07200	0.11250	0.13600
-6.00000	0.0	0.0	0.0	0.0	-0.00300	0.01600	0.06250	0.10000	0.12500
-4.00000	0.0	0.0	0.0	0.0	0.0	0.00500	0.04000	0.07600	0.10200
-3.00000	0.0	0.0	0.0	0.0	0.0	-0.00250	0.02600	0.06650	0.08700
-2.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.01300	0.05300	0.07000
-1.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.00350	0.03300	0.04500
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.00350	-0.03300	-0.04500
2.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.01300	-0.05300	-0.07000
3.00000	0.0	0.0	0.0	0.0	0.0	0.00250	-0.02600	-0.06650	-0.08700
4.00000	0.0	0.0	0.0	0.0	0.0	-0.00500	-0.04000	-0.07600	-0.10200
6.00000	0.0	0.0	0.0	0.0	0.00300	-0.01600	-0.06250	-0.10000	-0.12500
7.00000	0.0	0.0	0.0	0.0	0.00400	-0.02750	-0.07200	-0.11250	-0.13600
8.00000	0.0	0.0	0.0	0.00400	-0.00500	-0.04100	-0.08200	-0.12300	-0.14500
9.00000	0.0	0.0	0.0	0.00300	-0.01600	-0.05400	-0.08900	-0.13200	-0.15400
10.00000	0.0	0.0	0.00150	-0.00200	-0.03200	-0.06500	-0.10000	-0.14200	-0.16300
11.00000	0.0	0.0	0.00300	-0.01400	-0.04600	-0.07400	-0.10800	-0.14900	-0.17000
12.00000	0.0	0.0	-0.00200	-0.03000	-0.06000	-0.08300	-0.11600	-0.15700	-0.17600
13.00000	0.0	0.00150	-0.02500	-0.05000	-0.07400	-0.09300	-0.12200	-0.16300	-0.18400
14.00000	0.0	-0.02700	-0.05400	-0.06800	-0.08600	-0.10300	-0.12700	-0.16700	-0.18900
15.00000	-0.05400	-0.06500	-0.07300	-0.08400	-0.09700	-0.11100	-0.13300	-0.17300	-0.19500
16.00000	-0.07300	-0.07800	-0.08600	-0.09700	-0.10800	-0.11700	-0.13700	-0.17600	-0.20000
23.00000	-0.11200	-0.11800	-0.12800	-0.14400	-0.15700	-0.17100	-0.18300	-0.20600	-0.23200
30.00000	-0.17400	-0.18400	-0.19600	-0.21400	-0.23500	-0.25000	-0.26400	-0.27700	-0.29800
90.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
135.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
160.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
165.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
170.00000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 28. Concluded.

4.12 ROTOR-INDUCED VELOCITY DISTRIBUTION TABLE GROUP

The induced velocity distribution over each rotor can be computed using either an equation (given later in this section) or a Rotor-Induced Velocity Distribution (RIVD) table. IPL(12) controls the read-in of RIVD tables and the option of using a table or the equation.

Value of IPL(12)	RIVD Table(s) Required	Effect
0	None	Both rotors use equation
1	Rotor 1 table only	Rotor 1 uses table; Rotor 2 uses equation
2	Rotor 2 table only	Rotor 1 uses equation; Rotor 2 uses table
3	Both Rotor 1 and Rotor 2 tables	Each rotor uses its respective table

When a table is used, the local induced velocity is computed from the following summation:

$$v_i(\mu,\lambda,r/R,\Psi) = \bar{V}_i \left(a(1) + \sum_{n=1}^{NHH} a(2n)*\sin(n\Psi)+a(2n+1)*\cos(n\Psi) \right)$$

where

v_i = local induced velocity, ft/sec

$\bar{V}_i$ = average induced velocity over the rotor disc, ft/sec

μ = advance ratio (velocity in plane perpendicular to rotor shaft/tip speed)

λ = rotor inflow ratio

r/R = radial blade station (nondimensional)

Ψ = blade azimuth angle

a(i) = coefficients of the harmonics (nondimensional)

NHH = order of the highest harmonic

n = summation variable

The coefficients a(i) are computed from the table as functions of μ, λ, and r/R for the appropriate rotor. $\bar{V}_i$ is computed by an empirical equation given in Section 3.4.2 of Volume I of Reference 1. Note that the a(i) are velocities which have been normalized by $\bar{V}_i$.

An RIVD table itself consists of sets of Fourier coefficients that are derived from a curve fit of the above equation to data generated by a rotor wake analysis of the user's choosing. The a(i) must be normalized by the $\bar{V}_i$ for that μ and λ. Section 10.2 describes a program for generating the RIVD tables.

Each set of coefficients in the table corresponds to data at specific values of μ, λ, and r/R. The number of sets of coefficients in a table and the number of coefficients in a set are defined by the inputs on the Title and Control Card (CARD 100A or 110A). The permissible values of the integer inputs on these cards are:

Number of advance ratios: $1 \leq \text{NMU} \leq 3$

Number of inflow ratios: $1 \leq \text{NLM} \leq 2$

Number of harmonics: $0 \leq \text{NHH} \leq 6$

Number of radial stations (NRS): $0 \leq \text{NRS} \leq |\text{IPL}(4)| + 1$ (Rotor 1)

$0 \leq \text{NRS} \leq |\text{IPL}(5)| + 1$ (Rotor 2)

If either NMU or NLM is input as zero, it is reset to unity.

The radii for the blade stations used for the RIVD table must be input whenever NRS $\neq$ 0. The radial stations must coincide with radial stations used in the Rotor 1 Group (and Rotor 1 Elastic Blade Data Group, if input) but the RIVD tables may contain data for fewer radial stations than the other two groups. If fewer RIVD table stations are used, AGAP80 interpolates the values at the intermediate stations.

The number of coefficients in a set (NCA) is then

$$\text{NCA} = 2*\text{NHH} + 1$$

Which implies

$$1 \leq \text{NCA} \leq 13$$

Hence, one RIVD table may then consist of from 3 to 120 sets of 1 to 13 coefficients each (3 to 1560 total entries).

The RIVD table can be considered to be |IPL(4)| +1 (or |IPL(5)| +1) independent tables, with each one being a bivariant table in μ and λ at a given radial station.

During the rotor computations, a table lookup procedure is then used to obtain the set of coefficients a(i) from the appropriate radial station table. This table lookup procedure performs bivariant interpolation using the computed values of μ and λ whenever both values are within the range of their respective inputs. If a computed value is outside the range of its input, the procedure uses the input value that is closest to the computed value (i.e., the nearest boundary of the table); it does not extrapolate to a computed value. Note that the boundaries of a table can be pictured in a μ-λ plane as a rectangle (when both NMU and NLM are greater than unity), a line (when either NMU or NLM is unity, but the other is not), or a point (when both NMU and NLM are unity). Hence, in the trivial case (NMU = NLM = 1), the coefficients are dependent on radial station but independent of μ and λ. If only one of these control variables is unity, the coefficient will be independent of the associated ratio, but dependent on the other ratio as well as the radial station.

With regard to the input format of the sets of coefficients, it should be emphasized that only the constant coefficient is ever input in the first 10-column field on a card; each set must start on a new card. Inputs following the constant are in pairs (the sine and cosine components of the appropriate harmonic). When used, the fourth and seventh pairs of harmonic components start on a new card in the <u>second</u> 10-column field (columns 11 through 20 for the sine component). Only the cards necessary to input NHH harmonics are to be included in the sets of cards. For example, if NHH = 4, the third card described in Section 2.12.1.4 must be omitted.

If a Rotor-Induced Velocity Distribution Table is not used for a particular rotor, the distribution of the average induced velocity over the rotor disk is determined by use of an equation internal to the program. The equation is

$$v_i = \bar{V}_i \left\{ \frac{4}{3}\, x \,\left[1 + f_1(\mu) * \cos \Psi * \right.\right.$$
$$\left.\left. + f_2(x, \Psi) * f_1(\mu) * K_{27} \right] \sqrt{-0.5 * V_N^2 + \sqrt{0.25 * V_N^4 + (\bar{V}_i)_N^2}} \right\}$$

where v_i is the local induced velocity

$\bar{V}_i$ is the average induced velocity across the rotor disc

x is the nondimensional blade station (0 = root, 1 = tip)

Ψ is the blade azimuth angle

K_{27} is XMR(27) or XTR(27), as appropriate

V_N is the flightpath airspeed in ft/sec divided by 1.0 ft/sec

$(\bar{V}_i)_N$ is $\bar{V}_i$ in ft/sec divided by 1.0 ft/sec

The two functions, f_1 and f_2, are defined as follows:

$$f_1(\mu) = \begin{cases} 0.5 & \text{if } \Omega < 1 \text{ rad/sec} \\ 11.25\,\mu & \text{if } \Omega \geq 1 \text{ and } \mu < 0.1067 \\ 1.36 - 1.5\,\mu & \text{if } \Omega \geq 1 \text{ and } 0.1067 \leq \mu < 0.573 \\ 0.5 & \text{if } \Omega \geq 1 \text{ and } \mu \geq 0.573 \end{cases}$$

$$f_2(x, \Psi) = \begin{cases} 0.0 & \text{if } x < 0.7 \text{ or } (105^\circ < \Psi < 255^\circ) \\ & \text{or } (315^\circ \leq \Psi < 360^\circ) \text{ or } (0^\circ \leq \Psi < 45^\circ) \\ \sin 6(|\psi - 45^*) & \text{if } x \geq 0.7 \text{ and if } (45^\circ \leq \Psi \leq 105^\circ) \\ & \text{or } (255^\circ \leq \Psi \leq 315^\circ) \end{cases}$$

The f_2 function is intended to account for the tip vortex effect as discussed in Section 4.5. The calculation of $\bar{V}_i$ is described in Section 3.4 of Volume I of Reference 1.

4.13 ROTOR WAKE AT AERODYNAMIC SURFACES TABLES GROUP

The wake from each rotor that acts at each aerodynamic surface can be computed from either individual inputs or Rotor Wake at Aerodynamic Surface (RWAS) Tables. Exactly IPL(13) RWAS tables must be input where $0 \leq$ IPL(13) ≤ 12. However, RWAS tables are used only when inputs in the wing and/or stabilizing surface groups specify their use. For the wing, these controlling inputs are XWG(29) through XWG(32); for the i^{th} stabilizing surface group the controlling inputs are XSTBi(29) and XSTBi(32). See Sections 4.16 and 4.17 for details.

When a table is used, the velocity superimposed on the flow field at an aerodynamic surface due to rotor-induced velocity is computed from the following summation:

$$(v_i)_{jk} = (\bar{V}_i)_k \left\{ a(1) + \sum_{n=1}^{NHH} a(2n)*\sin(n\Psi_k) + a(2n+1)*\cos(n\Psi_k) \right\}$$

where $(v_i)_{jk}$ = superimposed velocity on the j^{th} surface due to the k^{th} rotor, ft/sec

$(\bar{V}_i)_k$ = average induced velocity across the disk of the k^{th} rotor, ft/sec

a(i) = coefficients of the harmonics (functions of μ and λ of the k^{th} rotor)

Ψ_k = azimuth angle of Blade 1 of the k^{th} rotor

NHH = order of the highest harmonic

n = summation variable

Note that if the k^{th} rotor uses the quasi-static rotor analysis, only the constant term, a(1), is included in the equation (i.e., the value of the summation of the harmonics during a complete rotor revolution is assumed to be zero). The above statement applies to each rotor, independent of the analysis being used on the other rotor.

As implied by the j and k subscripts above, each table is assumed to correspond to the effect a particular rotor has on a particular surface, e.g., the effect of Rotor 1 on the left wing panel, Rotor 2 on Stabilizing Surface No. 3. The 12 possible tables allow input of a separate table for

each combination of the two rotors and the six surfaces (two wing panels and four stabilizing surfaces).

It is emphasized that in preparing an RWAS table the input coefficients must be normalized by the value of $\bar{V}_i$ which is computed in this program for the appropriate rotor. Since inputs to the aerodynamic surface groups noted above can assign any one of the RWAS tables to simulate the defined effect of that input, care must be exercised to assure that the table used is based on the correct rotor-induced velocity and surface location. For example, XSTB2(32) can be used to specify the table which gives the effect of the Rotor 2 induced velocity on Stabilizing Surface No. 3; the referenced table must then have been normalized by the $\bar{V}_i$ of Rotor 2, and the μ and λ inputs must be for the tail rotor.

The composition of an RWAS table is essentially the same as an RIVD table except that the velocity computed from an RWAS table is not dependent on blade radial station. Hence, each set of coefficients in an RWAS table corresponds to the wake velocity at specified values of μ and λ and at a specific location with respect to the appropriate rotor. The number of sets of coefficients in a table and the number of coefficients in a set are defined by the inputs on the Title and Control Card. The permissible values of the integer inputs on this card are:

Number of advance ratios:	$1 \leq \text{NMU} \leq 3$
Number of inflow ratios:	$1 \leq \text{NLM} \leq 2$
Number of harmonics:	$0 \leq \text{NHH} \leq 1$

If NMU or NLM is input as zero, it is reset to unity. Hence, each RWAS table may consist of 1 to 6 sets of 1 to 3 coefficients (1 to 18 entries).

4.14 BASIC FUSELAGE GROUP (Include this group only if IPL(1) = 0)

CARD 121

Gross weight, XFS(1), is the total weight of the baseline configuration being simulated; i.e., it includes the fuselage, pylons, landing gear, empennage, rotors, fuel, crew, etc. However, this number must not include the weight of external stores included in the Store/Brake Group. Store weight is added to XFS(1) prior to commencing the TRIM procedure.

The Fuselage Data Reference Point defines the point of application of body lift, drag, and side force. When the fuselage aerodynamic inputs are based on wind tunnel data, the data reference point is the point on the wind tunnel model (in terms of full-scale inches) about which the force and moment data were resolved in data reduction.

CG location is for the total weight of the baseline configuration to be simulated, i.e., XFS(1), with 0 degrees mast tilt, stores off, and rotors unfolded. The cg location is internally recalculated prior to commencing the TRIM procedure for nonzero mast tilt with nonzero pylon weight, store weights greater than zero, and rotor folding. Note that the longitudinal centerline of the airframe must be buttline zero to be compatible with the aerodynamic surface and jet thrust models. Hence, lateral cg location must be with respect to this line.

CARD 122

Inertias are for the gross weight and cg location input on CARD 121, i.e., the total aircraft less stores. They are internally recalculated when external stores are added by the input data and when they are dropped during a maneuver.

The equation use indicator, XFS(12), and the low and high phasing angles, XFS(13) and XFS(14), are used only when fuselage aerodynamic equations are input (IPL(29) = 0).

The fuselage aerodynamic equation model contains two regimes for the fuselage aerodynamic forces and moments:

(1) the Nominal Angle Equation (NAE) regime and
(2) the High Angle Equation (HAE) regime

The NAE regime provides very precise simulation of wind tunnel data over a limited range of aerodynamic angles while the HAE regime is less precise, but provides simulation at all possible aerodynamic angles.

With the equation use indicator, XFS(12), and low and high phasing angles, XFS(13) and XFS(14) respectively, the user can specify the flight condition on which the inputs to the NAE regime are based and the aerodynamic angles where the program changes from the NAE regime to the phasing region to the HAE regime. This option allows the user to obtain the more precise simulation provided by the NAE regime in the flight condition for which the most accurate data is available.

The program calculates a complex angle of attack, α_C, which includes both angle of attack and sideslip. In forward flight it is defined as

$$\alpha_C = \cos^{-1} (u_{fus}/V)$$

where

u_{fus} = the body axis x velocity, including the components of rotor downwash in the body x direction

$V = \sqrt{u^2_{fus} + w^2_{fus}}$

w_{fus} = the body axis z velocity, including the components of rotor downwash in the body z direction.

This angle determines whether the NAE or HAE are to be used.

For the normal situation when flight test or analytical data are input for the NAE regime the simplest procedure is to set XFS(12), (13), and (14) all to zero. For these inputs, the NAE will be used only when α_C is less than 15 degrees; the HAE will be used only when α_C is greater than 35 degrees; and the two sets of equations will be phased together when α_C is between 15 and 35 degrees.

When both XFS(13) and (14) are input as zero, the program resets them to 15 and 35 degrees respectively as indicated above. For the case of forward-flight inputs to the NAE, it is only necessary that XFS(12) = 0.0 and XFS(13) be less than XFS(14), not that all three be zero. If the test data input for the NAE regime indicates that 15 and 35 are not the best phasing angles, the user should input better ones.

If test or analytical data are available for rearward or sideward flight, it is possible to specify that the NAE inputs are from one of these flight regimes and that the model should be used in that flight regime.

To specify that the NAE inputs are in a particular flight regime and are to be used there, use the following guidelines:

Forward Flight:	XFS(12) = 0.0, $\lvert XFS(13)\rvert < \lvert XFS(14)\rvert$
Rearward Flight:	XFS(12) = 0.0, $\lvert XFS(13)\rvert \geq \lvert XFS(14)\rvert$
Left Sideward Flight:	XFS(12) $\neq$ 0.0, $\lvert XFS(13)\rvert < \lvert XFS(14)\rvert$
Right Sideward Flight:	XFS(12) $\neq$ 0.0, $\lvert XFS(13)\rvert \geq \lvert XFS(14)\rvert$

When XFS(12) = 0.0, the definition of α_c is as above:

$$\alpha_c = \cos^{-1}(u/V)$$

However, when XFS(12) $\neq$ 0.0, the definition is

$$\alpha_c = \cos^{-1}(-v/V)$$

where v is the body axis Y velocity.

In other words, for XFS(12) = 0.0 (forward or rearward flight), α_c is with respect to the positive body X axis while for XFS(12) $\neq$ 0.0 (sideward flight), α_c is with respect to the negative body Y axis.

The regions where the NAE and HAE are active and the regions where they are phased together are then a function only of the relative magnitudes of XFS(13) and XFS(14).

If $\lvert XFS(13)\rvert < \lvert XFS(14)\rvert$, then only the NAE are active when

$$0 \leq \lvert\alpha_c\rvert \leq \lvert XFS(13)\rvert$$

while only the HAE are active when

$$\lvert XFS(14)\rvert \leq \lvert\alpha_c\rvert \leq 180$$

and the two sets of equations are phased together when

$$\lvert XFS(13)\rvert < \lvert\alpha_c\rvert < \lvert XFS(14)\rvert$$

If XFS(13) $\geq$ XFS(14), then only the NAE are active when

$$180 \geq \lvert\alpha_c\rvert \geq \lvert XFS(13)\rvert$$

while only the HAE are active when

$$|XFS(14)| \geq |\alpha_c| \geq 0$$

and the two sets of equations are phased together when

$$|XFS(13)| > |\alpha_c| > |XFS(14)|$$

The Nominal Angle Equations (NAE) and High Angle Equations (HAE) for a specific force or moment are phased together in the appropriate region by the following relationship:

$$(\text{Force or moment}) = (NAE)*\cos^2(\alpha_{ph}) + (HAE)*\sin^2(\alpha_{ph})$$

where $\alpha_{ph} = 0.5\,[\alpha_c - XFS(13)]/[XFS(14) - XFS(13)]$

The values of $\Delta\alpha$, $\Delta\psi$ and Δ(force of moment) input on CARDs 123 through 125 are used to modify the fuselage aerodynamic tables (IPL(29)$\neq$0). Note that these inputs have no effect when equations are used to represent the fuselage.

4.15 FUSELAGE AERODYNAMIC GROUP

The fuselage aerodynamic model computes the aerodynamic forces and moments of the rotorcraft body, tail boom and alighting gear. The aerodynamics of wings, stabilizing surfaces, stores, pylons and rotor are accounted for elsewhere in the C81 model.

Two separate aerodynamic representations are available for the fuselage. The user may choose the Fuselage Aerodynamic Equation Model (IPL(29) = 0) or the Fuselage Aerodynamic Table Model (IPL(29)≠0). Both models represent the fuselage forces and moments as fractions of two aerodynamic angles, θ_w and ψ_w;

$$\theta_w = \tan^{-1} (w/u)$$

$$\psi_w = -\sin^{-1} (v/V)$$

where u, v and w are respectively the x, y and z body-axis components of the free-stream (flightpath) velocity V. These are the angles normally recorded on a pyramidal balance during wind tunnel test. Note the ψ_w is <u>not</u> the sideslip angle.

Additionally, all the forces and moments have been normalized with respect to the free-stream dynamic pressure

$$q = 0.5\rho V^2$$

Since rotorcraft fuselages do not have a generally accepted reference area and volume to completely nondimensionalize the aerodynamic forces and moments, the inputs to the equations or tables are in terms of square feet for forces and cubic feet for moments.

4.15.1 Fuselage Aerodynamic Equations Group

The Fuselage Aerodynamic Equations Group is input when IPL(29) = 0.

CARDS 131 through 13C contain the coefficients of the High Angle and Nominal Angle Equations. As shown in the input guide (Section 2.15.1), the coefficients for each force and moment are grouped together on sets of two cards each. Most inputs are described as partial derivatives of the force or moment divided by dynamic pressure with respect to θ_w and/or ψ_w. The remaining inputs are angles and semidimensional forces and moments. The per-degree units are used only to give as much physical meaning to the inputs as possible. All inputs with per-degree units are actually coefficients of a sinusoid and are converted to per-radian units by the program.

Tables 11 through 16 contain the equations for the HAE and NAE models. Each table contains the equations for one of the forces or moments.

These equations were developed to provide very accurate simulation of wind tunnel data. The user is not expected to be able to define all 83 inputs without such test data. In particular, a complete set of inputs for the Nominal Angle Equations requires test data. If wind tunnel data are available, the digital computer program AN9101, described in Section 10.3, can be used to reduce the test data to coefficients which can be input directly to the program. If such data are not available, the 11 inputs with an asterisk beside them in Section 2.15.1 are considered to be the minimum necessary inputs. These inputs are YFS(1), (9), (15), (22), (23), (26), (29), (37), (50), (64), and (78)). Each is a coefficient in one of the Nominal Angle Equations. By using only these 11 inputs, the user has, in effect, assumed that all aerodynamic angles in the simulation will be small, i.e., less than 10 to 15 degrees, and that aerodynamic cross-coupling is negligible. Each Nominal Angle Equation which results from using only these eleven inputs is included in the appropriate table with the complete HAE and NAE models (Tables 11 through 16). The resulting equation is labeled as the Small Angle/Uncoupled Equation. These six equations are basically the same equations used in the AGAJ73 and earlier versions of C81.

When using the Small Angle/Uncoupled Equation all other inputs to the Nominal Angle Equations may be zero, and XFS(13) should be about 10 to 15 degrees, i.e., the accuracy limit of the input data. If the user is quite certain that α_C will not exceed XFS(13) during any simulation, the inputs to the HAE model may also be zero.

When the HAE model is needed, the inputs should be based on wind axis test data where the model was yawed to $\psi_W = \pm 180$ degrees at $\theta_W = 0$ and pitched to $\theta_W = \pm 90$ degrees at $\psi_W = 0$. If such data are not available, most of the inputs can be determined by estimating the fuselage drag and aerodynamic center location for sideward and vertical flight. The drag times the moment arms of the aerodynamic center about the data reference point will provide values for most of the moment inputs to the HAE model. Extrapolation of any available test data for a similar configuration could also be used.

TABLE 11. FUSELAGE LIFT EQUATIONS

High Angle Equation

$$L = q(L_1 * \cos^2\psi_w + L_2 * \sin^2\psi_w)$$

where
$$L_1 = \begin{cases} YFS(1) + L_3 * \sin^2\theta_w + L_4 * \sin(2\theta_w) & \text{if } \psi_w \le 90 \\ YFS(5) - L_5 * \cos^2\theta_w - L_4 * \sin(2\theta_w) & \text{if } \psi_w > 90 \end{cases}$$

$$L_2 = YFS(6) * \cos\theta_w + YFS(43) * \sin\theta_w$$

$$L_3 = YFS(5) - YFS(1)$$

$$L_4 = \frac{[YFS(3) - YFS(1) - L_3 * \sin^2(YFS(4)/RTD]}{\sin(2 * YFS(18)/RTD)}$$

$$L_5 = YFS(5) - YFS(2)$$

Nominal Angle Equation

$$\begin{aligned} L = {} & q\{[L_0/q + YFS(7) * RTD * \sin\psi_w + YFS(8) * RTD^2 * \sin^2\psi_w] \\ & + 0.5 * [YFS(9) * RTD + YFS(10) * RTD^2 * \sin\psi_w \\ & \quad + YFS(11) * RTD^3 * \sin 2c_w]\sin(2\theta_w) \\ & + 0.25 * [YFS(12) * RTD^2 + YFS(1?) * RTD3 * \sin\psi_w] * \sin^2(2\theta_w) \\ & + 0.125 * YFS(14) * RTD^3 * \sin^3(2\theta_w)\} \end{aligned}$$

where
$$L_0/q = \begin{cases} YFS(1) \text{ if } XFS(12) = 0.0 \text{ and } XFS(13) < XFS(14) \\ YFS(2) \text{ if } XFS(12) = 0.0 \text{ and } XFS(13) > XFS(14) \\ YFS(6) \text{ if } XFS(12) \ne 0 \end{cases}$$

Small Angle/Uncoupled Equation

$$L = q(L_0/q + YFS(9) * \theta_w)$$

where L_0/q is defined above

θ_w is in degrees

L = Lift in pounds (wind axis system)
YFS(1) through YFS(14) are the inputs on CARDS 131 and 132
RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 12. FUSELAGE DRAG EQUATIONS

High Angle Equation

$$D = q[D_1 * \cos^2\psi_w + YFS(17) * \sin^2\psi_w]$$

where

$$D_1 = D_2 * \cos^2\theta_w + D_v * \sin^2\theta_w$$

$$D_2 = \begin{cases} YFS(15) & \text{if } |\psi_w| < 90 \\ YFS(16) & \text{if } |\psi_w| > 90 \end{cases}$$

$$D_v = \begin{cases} YFS(18) & \text{if } \theta_w < 0 \\ YFS(19) & \text{if } \theta_w > 0 \end{cases}$$

Nominal Angle Equation

$$\begin{aligned} D = q\{ & [D_0/q + YFS(21) * RTD * \sin\psi_w + YFS(22) * RTD^2 * \sin^2\psi_w] \\ & + [YFS(23) * RTD + YFS(24) * RTD^2 * \sin\psi_w + YFS(25) * RTD^3 * \sin^2\psi_w] * \sin\theta_w \\ & + [YFS(26) * RTD^2 + YFS(27) * RTD^3 * \sin\psi_w] * \sin^2\theta_w \\ & + YFS(28) * RTD^3 * \sin^3\theta_w \} \end{aligned}$$

where

$$D_0/q = \begin{cases} YFS(15) & \text{if } XFS(12) = 0 \text{ and } XFS(13) < XFS(14) \\ YFS(16) & \text{if } XFS(12) = 0 \text{ and } XFS(13) > XFS(14) \\ YFS(17) & \text{if } XFS(12) \neq 0 \end{cases}$$

Small Angle/Uncoupled Equation

$$D = q[D_0/q + YFS(23) * \theta_w + YFS(26) * \theta_w^2 + YFS(22) * \psi_w^2]$$

where D_0/q is defined above

θ_w and ψ_w are in degrees

D = Drag in pounds (wind axis system)

YFS(15) through YFS(28) are the inputs on CARDS 133 and 134

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 13. FUSELAGE PITCHING MOMENT EQUATIONS

High Angle Equations

$$M = q[M_1*\cos^2\psi + M_2*\sin^2\psi]$$

where

$$M_1 = \begin{cases} YFS(29) + M_3*\sin^2\theta_w + M_4*\sin(2\theta_w) \text{ if } \psi_w \le 90 \\ YFS(33) - M_5*\cos^2\theta_w - M_4*\sin(2\theta_w) \text{ if } \psi_w > 90 \end{cases}$$

$$M_2 = YFS(71)*\sin\theta_w + YFS(34)*\cos^2\theta_w$$

$$M_3 = YFS(33) - YFS(29)$$

$$M_4 = \frac{[YFS(31) - YFS(29) - M_3*\sin^2(YFS(32)/RTD)]}{\sin(2*YFS(32)/RTD)}$$

$$M_5 = YFS(33) - YFS(30)$$

Nominal Angle Equation

$$\begin{aligned} M = q\{&[M_0/q + YFS(35)*RTD*\sin\psi_w + YFS(36)*RTD^2*\sin^2\psi_w] \\ &+ 0.5*[YFS(37)*RTD + YFS(38)*RTD^2*\sin\psi_w + YFS(39)*RTD^3*\sin^2\psi_w]*\sin(2\theta_w) \\ &+ 0.25*[YFS(40)*RTD^2 + YFS(41)*RTD^3*\sin\psi_w**\sin^2(2\theta_w) \\ &+ 0.125*YFS(42)*RTD^3*\sin^3(2\theta_w)\} \end{aligned}$$

where

$$M_0/q = \begin{cases} YFS(29) \text{ if } XFS(12) = 0 \text{ and } XFS(13) < XFS(14) \\ YFS(30) \text{ if } XFS(12) = 0 \text{ and } XFS(13) \ge XFS(14) \\ YFS(32) \text{ if } XFS(12) \ne 0 \end{cases}$$

Small Angle/Uncoupled Equation

$$M = q(M_0/q + YFS(37)*\theta_w)$$

where θ_w is in degrees and M_0/q is defined above

M = Pitching Moment in foot-pounds (wind axis system)

YFS(29) through YFS(42) are the inputs on CARDS 135 and 136

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 14. FUSELAGE SIDE FORCE EQUATIONS

High Angle Equation

$$Y = q[Y_1*\cos^2\theta_w - YFS(6)*\sin^2\theta_w*\sin\psi_w]$$

where $$Y_1 = YFS(43)*\sin\psi_w + Y_2*\sin(2\psi_w)$$

$$Y_2 = \frac{[YFS(44) - YFS(43)*\sin(YFS(45)/RTD)]}{\sin(2*YFS(45)/RTD)}$$

Nominal Angle Equation

$$\begin{aligned} Y = q\{&[YFS(46) + YFS(47)*RTD*\sin\theta_w + YFS(48)*RTD^2*\sin^2\theta_w \\ &+ YFS(49)*RTD^3*\sin^3\theta_w] \\ &+ 0.50*[YFS(50)*RTD + YFS(51)*RTD^2*\sin\theta_w + YFS(52)*RTD^3*\sin^2\theta_w]*\sin(2\psi_w) \\ &+ 0.25*[YFS(53)*RTD^2 + YFS(54)*RTD^3*\sin\theta_w]*\sin^2(2\psi_w) \\ &+ 0.125*[YFS(55)*RTD^3 + YFS(56)*RTD^4*\sin\theta_w]*\sin^3(2\psi_w)\} \end{aligned}$$

Small Angle/Uncoupled Equation

$$Y = q(YFS(46) + YFS(50) * \psi_w)$$

where ψ_w is in degrees

Y = Side Force in pounds (wind axis system)

YFS(43) through YFS(56) are the inputs on CARDS 137 and 138

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 15. FUSELAGE ROLLING MOMENT EQUATIONS

High Angle Equation

$$\ell = q[\ell_1 * \cos^2\theta_w + YFS(57) * \sin^2\theta_w * \sin\psi_w]$$

where $$\ell_1 = YFS(57) * \sin\psi_w + \ell_2 * \sin(2\psi_w)$$

$$\ell_2 = \frac{[YFS(58) - YFS(57) * \sin(YFS(59)/RTD)]}{\sin(2 * YFS(59)/RTD)}$$

Nominal Angle Equation

$$\begin{aligned}\ell = q\{&[YFS(60) + YFS(61) * RTD * \sin\theta_w \\ &\quad + YFS(62) * RTD^2 * \sin^2\theta_w + YFS(63) * RTD^3 \sin^3\theta_w] \\ &+ 0.5 * [YFS(64) * RTD + YFS(65) * RTD^2 * \sin\theta_w + YFS(66) * RTD^3 * \sin^2\theta_w] * \sin(2\psi_w) \\ &+ 0.25 * [YFS(67) * RTD^2 + YFS(68) * RTD^3 * \sin\theta_w] * \sin^2(2\psi_w) \\ &+ 0.125 * [YFS(69) * RTD^3 + YFS(70) * RTD^4 * \sin\theta_w] * \sin^3(2\psi_w)\}\end{aligned}$$

Small Angle/Uncoupled Equation

$$\ell = q(YFS(60) + YFS(64) * \psi_w)$$

where ψ_w is in degrees

ℓ = Rolling Moment in foot-pounds (wind axis system)

YFS(57) through YFS(70) are the inputs on CARDS 139 and 13A

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

TABLE 16. FUSELAGE YAWING MOMENT EQUATIONS

High Angle Equation

$$N = q[N_1 * \cos^2\theta_w - YFS(34) * \sin^2\theta_w * \sin\psi_w]$$

where $$N_1 = YFS(71) * \sin\psi_w + N_2 * \sin(2\psi_w)$$

$$N_2 = \frac{[YFS(72) - YFS(71) * \sin(YFS(73)/RTD)]}{\sin(2 * YFS(73)/RTD)}$$

Nominal Angle Equation

$$\begin{aligned} N = q\{&[YFS(74) + YFS(75) * RTD * \sin\theta_w \\ &+ YFS(76) * RTD^2 * \sin^2\theta_w + YFS(77) * RTD^3 * \sin^3\theta_w] \\ &+ 0.5 * [YFS(78) * RTD + YFS(79) * RTD^2 * \sin\theta_w + YFS(80) * RTD^3 * \sin^2\theta_w]\sin(2\psi_w) \\ &+ 0.25 * [YFS(81) * RTD^2 + YFS(82) * RTD^3 * \sin\theta_w]\sin^2(2\psi_w) \\ &+ 0.125 * [YFS(83) * RTD^3 + YFS(84) * RTD^4 * \sin\theta_w]\sin^3(2\psi_w)\} \end{aligned}$$

Small Angle/Uncoupled Equation

$$N = q(YFS(74) + YFS(78) * \psi_w)$$

where ψ_w is in degrees

N = Yawing Moment in foot-pounds (wind axis system)

YFS(71) through YFS(84) are the inputs on CARDS 13B and 13C

RTD = 57.296 (radians to degrees conversion) q = dynamic pressure

4.15.2 <u>Fuselage Aerodynamic Table Group</u>

The Fuselage Aerodynamic Table Group is input instead of the Fuselage Aerodynamic Equations Group whenever IPL(29)≠0. This group consists of a Group Identification Card, a Title and Control Card and six subtables containing the fuselage forces and moments (divided by dynamic pressure), as functions of θ_w and ψ_w.

The maximum size of each subtable is

$$NFSYAW(I) + NFSPCH(I) + NFSYAW(I)*NFSPCH(I) \leq 1100$$

The quantities of interest for the longitudinal aerodynamics (lift, drag, and pitching moment) are tabulated such that all values in a given row correspond to one angle of attack while all quantities in a given column correspond to one aerodynamic yaw angle (ψ_w). The lateral aerodynamic quantities (side force, rolling moment and yawing moment) are tabulated in reverse, i.e., a row corresponds to a particular aerodynamic yaw angle (ψ_w) and a column corresponds to a particular angle of attack. In either case, the first angle of attack and aerodynamic yaw angle (ψ_w) entered in the table must be the smallest value to be used, with the remainder of the angles being arranged in ascending order.

4.16 WING GROUP (Omit entire group if IPL(1) > 9 or IPL(15) = 0)

4.16.1 Basic Model

CARD 141

Wing area should include carry-through area if any. The program divides the area equally between the left and right wing panels.

The center of pressure and dihedral angle inputs (XWG(2), (3), (4), and (6)) are for the right wing panel. The left panel is assumed to be symmetrical to the right panel about the zero buttline plane. XWG(5) is the incidence angle of each panel when all primary flight controls are at 50 percent and the control surface deflection is zero. It is positive for leading edge up. Positive dihedral angle, XWG(6), means the outboard tip of each panel is up. See Figure 29.

The sweepback angle, XWG(7), is positive aft.

CARD 142

The geometric aspect ratio, XWG(8), is to be defined by the planform area in the plane of the sweepback angle and the span in the body Y-Z plane.

The spanwise efficiency factor, XWG(9), relates the geometric aspect ratio to the effective aspect ratio. See Section 4.16.2 for further details. A value of 0.66 to 0.70 has generally been used with success.

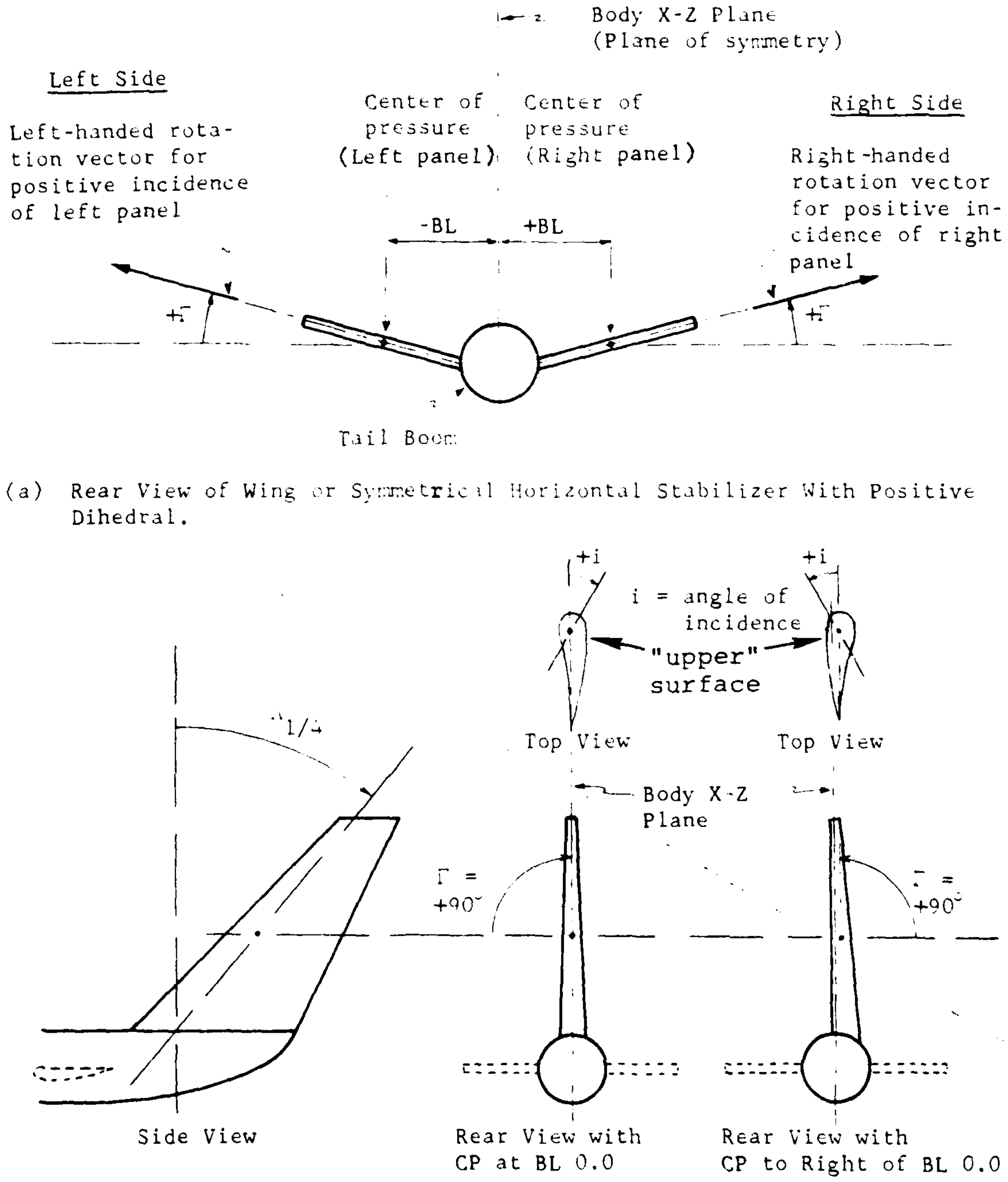
The taper ratio of the surface, XWG(10), is equal to the surface tip chord divided by the root chord; e.g., 1.0 is a parallelogram, 0.0 is a triangle.

XWG(11) and XWG(13) are used in calculating dynamic pressure loss at the stabilizing surfaces due to the wing, as discussed at the end of this section. The Wing Group does not have a counterpart to XSTB(11), the tailboom bending coefficient. Although similar in use, XWG(13) and XSTB1(13) are not necessarily equal. NACA reports have recommended a value of 2.42 for XWG(11).

XWG(12) is the dynamic pressure loss at the wing due to the fuselage.

$$q_{wing} = q_{free\ stream}\ (1.0 - XWG(12))$$

Control surface deflection, XWG(14), is positive for trailing edge down.



(b) Three-View of Swept Vertical Stabilizer With Center of Pressure on and to the Right of the Fuselage Plane of Symmetry.

Figure 29. Aerodynamic Surface Dihedral and Incidence Angles.

CARD 143

The model for changing surface lift coefficient, maximum lift coefficient, drag coefficient, and pitching moment coefficient with control surface, or flap, deflection is based on analysis and data from Reference 4 and Chapter 6 of Reference 5. The change in lift coefficient due to flap deflection, δ_f, is

$$(\Delta C_L)_f = XWG(15)*\delta_f + XWG(16)*\delta_f * \delta_f$$

and the change in maximum lift coefficient is

$$(\Delta C_L)_{max} = XWG(17)*\delta_f + XWG(18)*\delta_f^2 + (\Delta C_L)_f$$

The inputs XWG(17) and XWG(18) account for the situation where the maximum lift coefficient is increased more or less than the change in lift coefficient.

The change in profile drag coefficient due to flap deflection is

$$(\Delta C_D)_f = XWG(19)*\delta_f + XWG(20)*\delta_f^2$$

CARD 144

The change in pitching moment coefficient due to flap deflection is

$$(\Delta C_M)_f = XWG(22)*\delta_f + XWG(23)*\delta_f * \delta_f$$

CARD 145

XWG(29) through (32) control the effect of the wake from each rotor on the flow field at each wing panel. These effects are represented by superimposing two velocity vectors (one from each rotor) on the flow field at each panel. Each velocity vector is a function of the induced velocity at the specified rotor disc. The function may be either a constant or a value obtained from a Rotor Wake at Aerodynamic Surface (RWAS) Table. It is necessary that the four functions all be constants or all be from RWAS tables; combinations of constants and tables are not permitted.

---

[4]Young, A. D., THE AERODYNAMIC CHARACTERISTICS OF FLAPS, British Aeronautical Research Council RM No. 2622, February 1947 (also printed as R.A.E. Report Aero. 2185, August 1947).

[5]McCormick, B. W., Jr., AERODYNAMICS OF V/STOL FLIGHT, Academic Press, New York, 1967, pp. 167-193.

The magnitude of these wake effect inputs controls which function will be used. If the inputs are less than or equal to 100, four velocity vectors will be computed using the input values as constant factors:

$$(\Delta\dot{V})_{1R} = XWG(29)*(\bar{V}_i)_1$$

$$(\Delta\dot{V})_{1L} = XWG(30)*(\bar{V}_i)_1$$

$$(\Delta\dot{V})_{2L} = XWG(31)*(\bar{V}_i)_2$$

$$(\Delta\dot{V})_{2R} = XWG(32)*(\bar{V}_i)_2$$

where $\Delta\dot{V}$ is the velocity to be superimposed, and $\bar{V}_i$ is the average induced velocity at the rotor disc.

The numerical subscripts refer to the rotor, and the alphabetical subscripts to the wing panel (R = right, L = left). The velocities are defined to be parallel to their associated rotor shaft.

If the four inputs are greater than 100, 100 is subtracted from each input, and the RWAS table with the corresponding input sequence number is then used to supply a number that replaces the appropriate XWG input in the above equations. For example, if XWG(30) = 104.0, the fourth RWAS table will be used to compute the velocity vector at the left wing panel due to the wake of Rotor 1.

It is emphasized that if one effect is to be represented by a constant, all four effects must be represented by a constant; similarly, if one effect is to be represented by a table, all must be represented by a table. When using tables, care should be exercised to assure that the proper table is used. See Section 4.13 for a discussion of the RWAS tables. However, these restrictions on tables or constants apply only to a single aerodynamic surface; i.e., the type of representation used by the wing or any one of the four stabilizing surfaces does not affect the representation used by any other aerodynamic surface.

CARDS 146 and 147

Inputs XWG(33) through XWG(42) are based on data from Reference 6. They are used to calculate the wing contribution to static and dynamic stability. The static derivatives (those which are coefficients of β) may be included in the fuselage aerodynamics or simulated with appropriate values of wing sweep and/or dihedral. If this is done, XWG(33), (34), (37), and (38) should be set to zero. It is not possible to simulate the dynamic derivatives (those which are coefficients of p and r) with any other section of the program. In the Force and Moment Summary of the program output, one-half of the increments to the rolling and yawing moments calculated from the equations below is added to each wing panel.

$$\Delta L_w = F[\beta*[XWG(33) + XWG(34)*C_L]$$
$$+ ts*[XWG(35)*r*C_L + XWG(36)*p]]$$

and

$$\Delta N_w = F[\beta*[XWG(37) + XWG(38)*C_L{}^2]$$
$$+ ts*[r*\{XWG(39)*C_L{}^2 + XWG(40)*C_{D_O}*\cos\beta\}$$
$$+ p*\{XWG(41)*C_L + XWG(42)*(dC_D/d\alpha)*\cos\beta\}]]$$

where

F = $0.5\rho SV^2B$

ts = 0.5 B/V

V = airspeed

B = wing span

S = wing area

β = sideslip angle

α = wing angle of attack

p = roll rate of fuselage in the stability axis system

---

[6]Etkin, Bernard, DYNAMICS OF FLIGHT, New York, John Wiley and Sons, Inc., 1959, pp. 486-495.

r = yaw rate of fuselage in the stability axis system

L = roll moment of wings due to rates and sideslip

N = yaw moment of wings due to rates and sideslip

ΔL_w and ΔN_w are computed in the stability axis system and are resolved into the body axis system.

4.16.2 Aerodynamic Inputs for Stabilizing Surfaces and Wing

The last four cards of each aerodynamic surface input group define surface aerodynamics: YWG(1-28), YSTB1(1-28), YSTB2(1-28), YSTB3(1-28), and YSTB4(1-28). These inputs are used in conjunction with inputs from the corresponding XWG or XSTBi (i=1 to 4) arrays to compute the lift, drag, and pitching moment coefficients of each surface. The user has the option of specifying that the coefficients be computed from equations or obtained from data tables. In the following discussion, Y(I) refers to the Ith aerodynamic input, YWG(I) or YSTBi(I), for the appropriate aerodynamic surface and X(J) refers to the Jth input in the corresponding XWG or XSTBi array.

If the control variable Y(18) equals zero, subroutine CLCD computes the aerodynamic coefficients from equations as functions of the angle of attack, α; angle of sideslip, β; Mach number, M; surface planform geometry; and the spanwise efficiency factor, e. If Y(18)>0, the data tables are used to compute the coefficients as described at the end of this section and in the discussion of the Data Table Group.

When Y(18) = 0, the aerodynamic inputs are coefficients of equations that describe the infinite aspect ratio, or two-dimensional, aerodynamic coefficients of the airfoil section of the surface. It is assumed that the section is constant along the span and parallel to the longitudinal centerline of the aircraft. Subroutine CLCD then corrects the input data for finite aspect ratio, A; sweepback of the quarter chord line, $\Lambda_{1/4}$; sideslip angle between the airfoil section and local flow, β; change in maximum lift coefficient due to control surface deflection; and change in lift, drag, and pitching moment coefficients due to control surface deflection. Note that all angles of attack used in this model are zero-lift-line angles of attack. The model was developed to simulate the characteristics of symmetrical airfoils. If cambered airfoils are to be modeled and the angle between the chord-line and zero lift line of the section is more than a few degrees, it is suggested that data tables rather than equations be used.

The geometry and effectiveness of the surface are defined from the following inputs.

$\bar{y}$ = buttline of surface center of pressure = X(3)

$\Lambda_{1/4}$ = sweepback of quarter chord = X(7)

A = geometric aspect ratio = X(8)

e = spanwise efficiency factor = X(9)

λ = taper ratio of surface = X(10)

The spanwise efficiency factor, e, should be unity for the ideal case where the surface has an elliptical lift distribution and uniform downwash. However, the ideal case is the exception, not the rule, and the value of e is rarely unity. Factors which affect the value of e are the geometry of the surface (including aspect ratio, taper, and sweep) and the degree of end plating caused by adjacent structure.

Analytical prediction of e is difficult at best. A surface which has a large end plate may have a value of e as high as 1.5 or more. A straight untapered, unswept surface may have a value of e as low as 0.6 or less. A typical value of e for unend-plated aerodynamic surfaces on helicopters is about 0.7. The user should consult such reference books as Etkin, DATCOM, Perkins and Hage, or Dommasch (References 6, 7, 8, and 9) to obtain a more intuitive feel for the value which should be chosen for this spanwise efficiency factor.

Using the above parameters, the sweepback of the half chord, $\Lambda_{1/2}$, is

$$\Lambda_{1/2} = \tan^{-1} [\tan \Lambda_{1/4} - (1 - \lambda)/(A(1 + \lambda))]$$

and the effective sweepback angle, Λ^*, and effective aspect

---

[7] USAF STABILITY AND CONTROL DATCOM, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, February 1972.

[8] Perkins, C. D., and Hage, R. E., AIRPLANE PERFORMANCE STABILITY AND CONTROL, John Wiley and Sons, Inc., New York, 1967, page 93.

[9] Dommasch, D. O., Sherby, S. S., and Conolly, T. F., AIRPLANE AERODYNAMICS, Pitman Publishing Corporation, New York, 1967, page 158.

ratio, A^*, are

$$\Lambda^* = \Lambda_{1/2} - (\text{sign } \bar{y})\beta$$

$$A^* = eA \cos^2 (\Lambda^*)/ \cos^2 (\Lambda_{1/2})$$

Let α_1 be the angle of attack input to CLCD and assume that

$$-180° < \alpha_1 \leq 180°$$

Then for unstalled flow, the two-dimensional subsonic lift curve slope, a_o, is defined as

$$a_o = Y(8) + Y(9)*M + Y(10)*M^2 + Y(11)*M^3$$

the three-dimensional subsonic lift curve slope, a_1, as

$$a_1 = (2\pi A^*/57.3)/ \left[2 + \sqrt{(2-A^*/a_o)^2 \left[1 + \{\tan^2\Lambda^*/(1-M^2)\}\right] + 4}\right]$$

the transonic lift curve slope, a_2, as

$$a_2 = B_o + B_1 M + B_2 M^2$$

and the supersonic lift curve slope, a_3, as

$$a_3 = (4/57.3)/ \sqrt{M^2 - 1}$$

The input value for the lower boundary of the supersonic region, Y(2), is checked against a calculated value M_{sc}:

$$M_s = \text{Max } \{Y(2), M_{sc}\}$$

where

$$M_{sc} = \sqrt{1 + [(4/57.3)/(a_1)_{CR}]^2}$$

and $(a_1)_{CR}$ is a_1 evaluated at the drag divergence Mach number, Y(1). The coefficients B_0, B_1, and B_2 are computed internally by equating a_2 to a_1 and a_3, and the slope of a_2 to that of a_3 as follows:

$$a_2 = a_1 \qquad \text{at } M = Y(1),\ \beta = 0$$

$$a_2 = a_3 \qquad \text{at } M = M_s$$

$$\frac{da_2}{dM} = \frac{da_3}{dM} \qquad \text{at } M = M_s$$

Then the lift curve slope of the surface for unstalled flow, a, is defined as

$$a = \begin{cases} a_1 \text{ if } M < Y(1) \\ a_2 \text{ if } Y(1) \leq M < M_s \\ a_3 \text{ if } M_s \leq M \end{cases}$$

Having determined the unstalled lift curve slope, subroutine CLCD establishes the curve of C_L versus α for all the angles of attack.

If $|\alpha_1| \leq 90°$, i.e., forward flight,

$$\alpha = |\alpha_1|$$

$$SG = \alpha_1 / |\alpha_1|$$

$$C_{L_0} = \text{Min}\ (Y(3),\ 1.21A^*) + SG(\Delta C_L)_{max}$$

$$K_L = Y(4)*M + Y(5)*M^2 + Y(6)*M^3$$

$$\alpha_S = (C_{L_0} + K_L)/a$$

$$\alpha_B = \alpha_S + 5°$$

where $(\Delta C_L)_{max}$ is the increment to the maximum lift coefficient due to control surface deflection, as calculated in the aerodynamic surface section.

If $\alpha_1 > 90°$, i.e., rearward flight or reversed flow,

$$\alpha = 180° - |\alpha_1|$$

$$SG = -\alpha_1 / |\alpha_1|$$

$$C_{L_0} = \text{Min}\ (Y(7),\ 1.21A^*) + SG(\Delta C_L)_{max}$$

$$K_L = 0$$

$$\alpha_S = C_{L_0}/a$$

$$\alpha_B = \alpha_S + 5°$$

The Min function in the expressions for C_{L_0} is included to reduce the value of maximum lift coefficient when the effective aspect ratio, A*, decreases significantly. In particular, according to vortex lift theory, the maximum lift coefficient for very low aspect ratio surfaces is 1.21 times the (effective) aspect ratio. Hence, if the $C_{L_{MAX}}$ based on vortex lift theory is less than the input value (Y(3) for normal flow, Y(7) for reversed flow), the value is reset to 1.21A*.

For $0 \le \alpha \le \alpha_B$

$$C_L' = a\alpha$$

If $C_L' \le C_{L_0}$, then

$$C_L = C_L' + SG(\Delta C_L)_f$$

where $(\Delta C_L)_f$ is the increment to C_L due to flap deflection as calculated in the aerodynamic surface section.

If $C_L' > C_{L_0}$, then C_L is determined by linear interpolation in the following manner.

$$C_{L_{max}} = C_{L_0} + K_L + SG(\Delta C_L)_f$$

$C_{L_B} = C_L$ at $\alpha = \alpha_B$ as discussed below.

Then

$$C_L = C_{L_{max}} + (C_{L_{max}} - C_{L_B})(\alpha - \alpha_S)/5°$$

In either case, the induced angle of attack, α_i, is

$$\alpha_i = C_L/\pi A^*$$

For $\alpha_B \leq \alpha \leq 90°$, the lift coefficient is calculated from the following empirical expression for C_L as a function of the equivalent two-dimensional angle of attack, α_2,

$$C_L = \{2\ C_{L_0} \sin \alpha_2 - .81\}K_3 + 0.81 \quad \cos \alpha_2 + SG^*(\Delta C_L)_f$$

$$K_3 = \begin{cases} 1 + 0.25\ M^4 \text{ if } M \leq 1 \\ 0.84 + 0.082/(M-0.8) \text{ if } M > 1 \end{cases}$$

The value of C_{L_0} is based on the magnitude of α_1 as described above, and ΔC_L is the increment due to control surface deflection.

The angle α_2 is related to the angle α by the induced angle of attack, α_i.

$$\alpha_2 = \alpha - \alpha_i$$

where, as above, $\alpha_i = C_L / \pi A^*$

The angle α_2 represents the angle of attack needed on an infinite aspect ratio surface to provide the same lift as the aerodynamic surface in question.

Hence, C_L and α_i are functions of each other. Consequently, a small angle assumption is used for α_i and the above expressions for C_L, α_2, and α_i are rearranged to define α_i as a function of C_{L_0}, α, and K_3.

Then

$$C_L = \pi(A^*)\alpha_i$$

The form of the C_L versus α curve is shown in Figure 24 for zero control surface deflection. At point P_1 in the figure,

$$C_L = C_{L_0} + K_L$$

$$\alpha = \alpha_S = C_L/a$$

At point P_2 in Figure 24,

$$\alpha = \alpha_B$$

and C_L is defined by the procedure discussed for $\alpha_B \le \alpha \le 90°$. Control surface deflection shifts the curve vertically and may change the difference between C_L at $\alpha = 0$ and C_L at $\alpha = \alpha_S$.

The form of the C_D versus α curve is shown in Figure 25. At point P_3 in Figure 25, $\alpha = \alpha_X$ and $C_D = C_{D_X}$. The values of α_X and C_{D_X} are defined from the maximum value for nondivergent drag, Y(16); the stall angle, α_S; and the equation for non-divergent drag, $(C_D)_{ND}$.

$$(C_D)_{ND} = Y(12) + Y(13)*\alpha_2 + Y(14)*\alpha_2 2 + (\Delta C_D)_f$$
$$+ \text{Max}\{0, Y(19)*\alpha_2 - Y(1) + \text{Max}|M, 0.35|\}$$

where $\alpha_2 = \alpha - \alpha_i$, as in the model for lift coefficient,

$(\Delta C_D)_f$ = increment to profile drag due to control surface (flap) deflection and

C_{D_S} = $(C_D)_{ND}$ evaluated at $\alpha_2 = \alpha_S - (\alpha_i)_S$

If $C_{D_S} \le Y(16)$

$$\alpha_X = \alpha_S - (\alpha_i)_S$$

$$C_{D_X} = C_{D_S}$$

If $C_{D_S} > Y(16)$

$$C_{D_X} = Y(16)$$

$$\alpha_X = \alpha_2 \text{ for } (C_D)_{ND} = Y(16)$$

Then, for $0 \leq |\alpha| \leq \alpha_X$

$$C_D = (C_D)_{ND}$$

and for $\alpha_X < |\alpha| \leq 90°$

$$C_D = 2. + (\alpha_2 - 90°)^2 (C_{D_X} - 2.)/(\alpha_X - 90°)^2$$

In the supersonic region, $M > M_S$

$$C_D = \text{Min} \left\{ Y(16), \quad (Y(12) + 4[(\alpha_2/57.3)^2 + Y(15)]/\sqrt{M^2 - 1} \right\}$$

The value usually used for Y(15) is 0.04. The supersonic lift and drag for the wing and stabilizing surfaces is de-emphasized because this computer program was never intended to simulate such high-speed flight. The supersonic functions are included primarily because the C_L and C_D calculations were originally developed for the rotors and later were applied to the other aerodynamic surfaces. A secondary reason for this inclusion is to maintain the similarity between the input and mathematical models used for the aerodynamic surfaces (CLCD subroutine) and the rotors (CDCL subroutine).

Once determined, the C_L and C_D coefficients are assumed to act in an axis system which is pitched up α_i degrees with respect to the wind vector. Consequently, before returning the value of C_L and C_D to the aerodynamic surface section of the program, they are resolved back to wind axis,

$$C_{L_{wind}} = C_L \cos \alpha_i - C_D \sin \alpha_i * SG$$

$$C_{D_{wind}} = C_D \cos \alpha_i + C_L \sin \alpha_i * SG$$

The calculation of the aerodynamic pitching moment is performed in the same manner as for the rotor except that the section pitching moment coefficient, Y(25), is modified for sweep and aspect ratio effects. That is, substitute the following expression for Y(25) in the rotor discussion:

$$Y(25) = A^* \cos^2(\Lambda_{1/4})/(A^* + 2\cos(\Lambda_{1/4})) + (\Delta C_M)_f$$

where $(\Delta C_M)_f$ is the increment to pitching moment due to control surface (flap) deflection.

It is possible to use sets of data tables for determining the aerodynamic coefficients as a function of α and M. The tables available for use are those input to the Data Table Group.

If Y(18) > 0, the Y(18)th airfoil data table is used to determine the coefficients as functions of α_1 and M.

<u>CAUTION</u>:

Coefficients obtained from tables are <u>not</u> corrected for aspect ratio or sweep effects. Hence, the data in tables to be used by aerodynamic surfaces must be for the specific surface which is being simulated, i.e., three-dimensional test data at zero sideslip. Data from tables are corrected for yawed flow and control surface deflection as follows:

$$C_L = [(C_L)_{Table} + (\Delta C_L)_f] \cos^2(\Lambda^*)/\cos(\Lambda_{1/2})$$

$$C_D = [(C_D)_{Table} + (\Delta C_D)_f]$$

$$C_M = [(C_M)_{Table} + (\Delta C_M)_f] \cos^2(\Lambda^*)/\cos(\Lambda_{1/2})$$

<u>NOTE</u>: If tables are used by the wing, the wing aerodynamic inputs should still be input to provide a realistic value for the stall angle, α_S. This angle is used in computing the effect of the wing on the flow field at the stabilizing surfaces.

4.16.3 Flow Field at Stabilizing Surfaces due to Wing

As mentioned in the discussion of Stabilizing Surface No. 1, the wing can affect the flow field at the stabilizing surfaces. It does so in the following manner.

A dynamic pressure reduction at each surface due to the wing is calculated using XWG(11) and (13). The equations used were taken from NACA Report Number 648, Reference 10. The general situation is shown in Figure 30.

The deflection of the centerline of the wing wake from the free-stream direction, ε_{wake}, is calculated from XWG(13).

$$\varepsilon_{wake} = XWG(13)*C_{L_{wing}}$$

The dynamic pressure loss, η_q, is represented as a fractional part of the free-stream value such that

$$q_{reduced} = q_{free\ stream}(1-\eta_q)$$

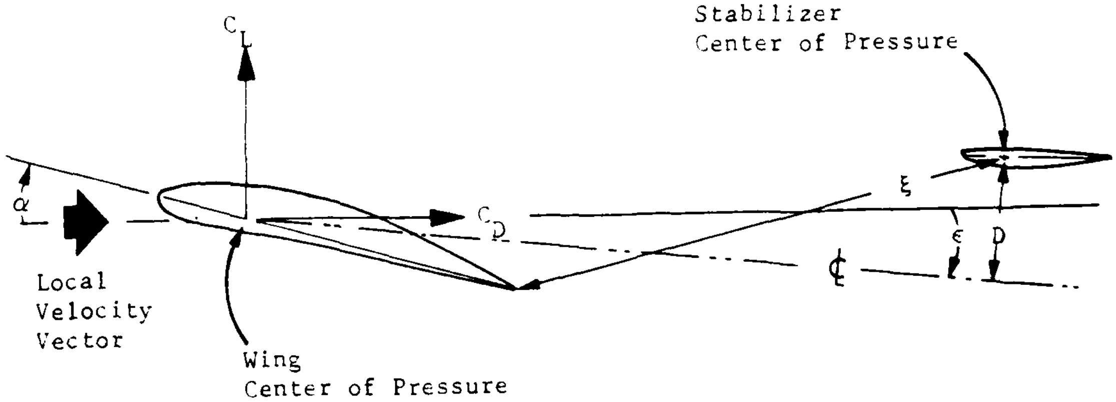
The maximum value of η_q occurs at the center of the wing wake and at the trailing edge of the wing. The input XWG(11) is used to determine this maximum reduction, $\eta_{q_{max}}$.

$$\eta_{q_{max}} = XWG(11)* \quad C_{D_{wing}}^{\ 1/2}$$

Then the dynamic pressure loss may be calculated at any point inside the wing wake.

$$\eta_q = \frac{\eta_{q_{max}} \cos^2 (\pi D/2h)}{(\xi + 0.3)}$$

[10]Silverstein, A., and Katzoff, S., DESIGN CHARTS FOR PREDICTING DOWNWASH ANGLE AND WAKE CHARACTERISTICS BEHIND PLAIN AND FLAPPED WINGS, NACA Report No. 648, 1939.



$\mathbb{C}$ is the centerline of the wing wake.

The figure is in the body X-Z plane.

Figure 30. Wing Wake Model.

where

D is the vertical distance from the centerline of the wake to the elevator (as shown in Figure 30),

h is the half width of the wing wake at the elevator station, and

ξ is the distance of the elevator behind the wing trailing edge normalized by the wing mean aerodynamic chord (as shown in Figure 30).

D, h, and ξ are internally calculated based on wing/stabilizing surface geometry and aerodynamics.

In addition, a downwash angle at each surface due to the wing is computed using the 13th input of the appropriate stabilizing surface, e.g., XSTB1(13) for Surface No. 1. The angle for Surface No. 1 is then

$$\varepsilon_{wash} = \mathrm{XSTB1(13)} * C_{L_{wing}}$$

Note that although XWG(13) and XSTB1(13) are used in similar-looking equations, they are different inputs and in most cases have different values.

Using ε_{wash} and η_q, the flow field is then modified at the stabilizing surface in the same manner as was done for the downwash and dynamic pressure reduction at the surface due to the fuselage.

See Section 4.16.2 for the discussion of the wing aerodynamic computations.

4.16.4 Control Linkage Inputs

Because of the similarity of the control linkage models for the wing and the stabilizing surfaces, the control linkage inputs for both are discussed in this section. The wing controls subgroup is XCWG, while the corresponding subgroups for the stabilizing surfaces are XCS1, XCS2, XCS3, and XCS4 for the first, second, third, and fourth surfaces, respectively. In the following discussion, the term XCSj(I) refers to the I^{th} input of the j^{th} stabilizing surface linkage subgroup. The

wing linkage subgroup can be considered equivalent to the zeroth surface subgroup, i.e., XCS0(I) is synonymous with XCSW(I). Similarly, XSTBj(k) refers to the K^{th} input of the j^{th} basic surface group with XSTB0(K) and XWG(K) being equivalent.

The inputs to each subgroup define the control linkages from the primary flight controls and the longitudinal mast tilt angle of Rotor 1 to the incidence or control surface deflection angles of the corresponding aerodynamic surface. The linkages can be either linear or parabolic.

The reading of XCWG is controlled by IPL(15). If IPL(15) > 0, the XCWG inputs (CARDS 14B and 14C) must be included; if IPL(15) < 0, the two cards must be omitted.

The read-in of the linkage subgroup for the stabilizing surface is controlled by IPL(16) through IPL(19). If one of these values is positive, then that Stabilizing Surface Group must include a Linkage Subgroup. If the value is negative, the Linkage Subgroup must be omitted.

Each subgroup uses the identical input format and the same mathematical model for calculating the increments to be added to the incidence or control surface deflection angle of the surface. However ,the wing is divided into left and right panels, with the inputs controlling the right panel. For collective or longitudinal cyclic stick linkages, the increments are added to each wing panel symmetrically; for lateral cyclic stick or pedal position linkages, the increments for the left panel are the negative of those on the right (i.e., asymmetric deflection).

The primary flight controls cannot be linked to incidence and control surface deflection simultaneously. If XCSj(7) = 0, control linkages will change only the incidence angle, XSTBj(5), of the surface. If XCSj(7) $\neq$ 0, the linkage will change only the control surface deflection, XSTBj(14). During maneuvers, incidence and/or control surface deflection may be changed independently of the control linkages described in this section (see Section 4.29.2.27). Either or both angles can be changed in maneuver regardless of the value of XSCj(7).

XCSj(3), (6), (10), and (13) define breakpoints in the curves of the control linkages. These breakpoints permit control linkages that provide a zero increment to the appropriate angle of the surface if the control is to one side of the breakpoint and a nonzero value when the control is to the opposite side.

If XCSj(3) = 0.0, the increment for the j^{th} surface due to collective stick displacement is

$$(\Delta i_1)_j = XCSj(1) * K_1 + XCSj(2) * K_1^2$$

If XCSj(6) = 0.0, the increment for the j^{th} surface due to longitudinal cyclic stick displacement is

$$(\Delta i_2)_j = XCSj(4) * K_2 + XCSj(5) * K_2^2$$

If XCSj(10) = 0.0, the increment for the j^{th} surface due to lateral cyclic stick displacement is

$$(\Delta i_3)_j = XCSj(8) * K_3 + XCSj(9) * K_3^2$$

If XCSj(13) = 0.0, the increment for the j^{th} surface due to pedal displacement is

$$(\Delta i_4)_j = XCSj(11) * K_4 + XCSj(12) * K_4^2$$

where K_1, K_2, K_3, and K_4 are the control deflections in inches from the 50-percent control position. The total increment to the appropriate angle of the jth surface due to the primary flight controls is then

$$\Delta i_j = (\Delta i_1)_j + (\Delta i_2)_j + (\Delta i_3)_j + (\Delta i_4)_j$$

The effect of a nonzero breakpoint for the collective stick linkage, XCSj(3) ≠ 0, is discussed below. The effects of nonzero XCSj(6), (10), and (13) are identical.

If XCSj(3) > 0, then the control linkage is active only when the magnitude of the stick position is greater than the breakpoint, i.e.,

$$(\Delta i_1)_j = 0, \text{ if } \delta_{COLL} \leq XCSj(3)$$

$$= XCSj(1) * k_1 + XCSj(2) * k_1^2, \text{ if } \delta_{COLL} > XCSj(3)$$

and if XCSj(3) < 0, then the control linkage is active only when the magnitude of the stick position is less than the magnitude of the breakpoint, i.e.,

$$(\Delta i_1)_j = 0, \text{ if } \delta_{COLL} \geq XCSj(3)$$

$$= XCSj(1) * k_1 + XCSj(2) * k_1^2, \text{ if } \delta_{COLL} < XCSj(3)$$

where $k_1 = (\delta_{COLL} - |XCSj(3)|) * XCON(1)/100$.

For constant values of XCSj(1) and (2), the effect of the breakpoint on the increment is shown in Figure 31.

Similarly, the increment due to longitudinal cyclic with XCSj(6) $\neq$ 0 is as follows:

if XCSj(6) > 0,

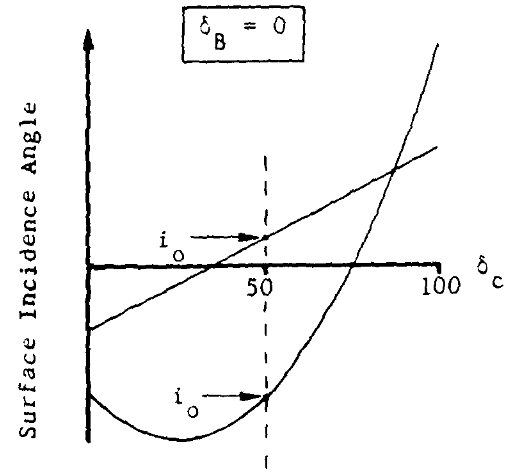
$$(\Delta i_2)_j = 0 \text{ if } \delta_{LONG} \leq XCSj(6)$$

$$= XCSj(4) * k_2 + XCSj(5) * k_2^2 \text{ if } \delta_{LONG} > XCSj(6)$$

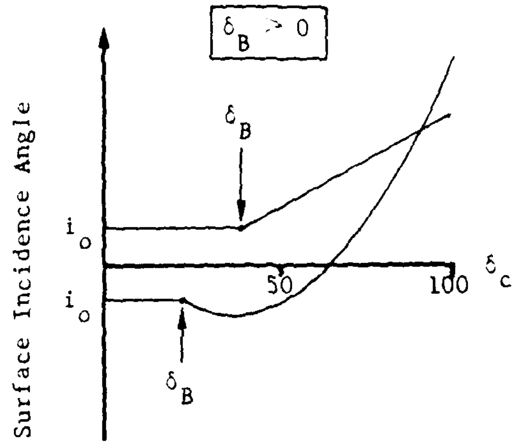
and if XCSj(6) < 0,

$$(\Delta i_2)_j = 0 \text{ if } \delta_{LONG} \geq XCSj(6)$$

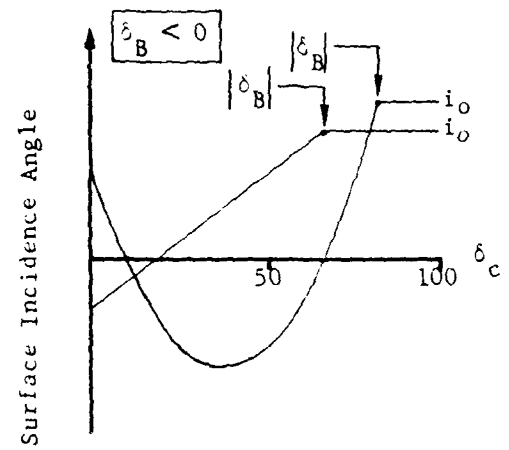
$$= XCSj(4) * k_2 + XCSj(5) * k_2^2 \text{ if } \delta_{LONG} < XCSj(6)$$



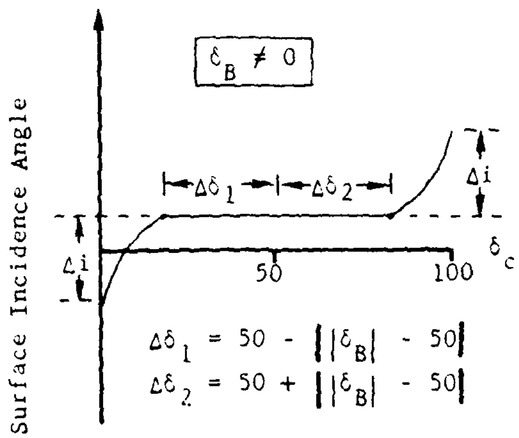
(a) Linear and parabolic linkages, no breakpoint.



(b) Linear and parabolic linkages, positive breakpoint.



(c) Linear and parabolic linkages, negative breakpoint.



(d) Parabolic linkages from pedals or lateral cyclic to wing, nonzero breakpoint.

δ_c = Control position, percent of full throw

δ_B = Control position for breakpoint, percent

i_o = Basic (input) incidence angle for surface, degrees

Figure 31. Aerodynamic Surface Control Linkages.

where $k_2 = (\delta_{LONG} - |XCSj(6)|) * XCON(7)/100$

For the stabilizing surfaces, the increments due to lateral cyclic, $(\Delta i_3)_j$, are computed similarly by replacing XCSj(4), (5), and (6) with XCSj(8), (9), and (10) plus replacing δ_{LONG} and XCON(7) with δ_{LAT} and XCON(15). For the increment due to pedal, $(\Delta i_4)_j$, XCSj(11), (12), (13), δ_{PED}, and XCON(22) are substituted.

For the lateral cyclic and pedal linkages to the wing angles, nonzero breakpoints, XCWG(10) or (13), operate in a slightly different manner from that discussed above. As shown in Figure 31 the linkage is asymmetrical about the 50-percent control position. In equation form, the increment added to the right panel is

$$(\Delta i_3)_0 = XCWG(8) * k_3 + XCWG(9) * k_3^2$$

where

$$k_3 = \begin{cases} (\delta_{LAT} - \delta_2) * XCON(17)/100, & \text{if } \delta_{LAT} > \delta_2 \\ (\delta_{LAT} - \delta_1) * XCON(17)/100, & \text{if } \delta_{LAT} < \delta_1 \\ 0, & \text{if } \delta_1 \leq \delta_{LAT} \leq \delta_2 \end{cases}$$

and
$$\left.\begin{array}{l} \delta_1 = 50 - XCWG(10) \\ \delta_2 = 50 + XCWG(10) \end{array}\right\} \quad XCWG(10) > 0$$

The increment added to the left wing panel is the negative of the increment added to the right panel. The increment to each panel due to pedal position is handled in an identical manner.

An increment, Δi_m, can be added to the appropriate surface angle as a function of the longitudinal mast tilt of Rotor 1.

$$(\Delta i_m)_j = XCSj(14) * (\text{longitudinal mast tilt angle})$$

The total increment to the appropriate angle of the j^{th} surface is then

$$\Delta i_j = (\Delta i_1)_j + (\Delta i_2)_j + (\Delta i_3)_j + (\Delta i_4)_j + (\Delta i_m)_j$$

If XCSj(7) = 0, the geometric angle of incidence for the j^{th} surface is then

$$i_j = \Delta i_j + \text{XSTBj}(5)$$

and the control surface angle is

$$\delta_j = \text{XSTBj}(14)$$

If XCSj(7) $\neq$ 0,

$$i_j = \text{XSTBj}(5)$$

and

$$\delta_j = \Delta i_j + \text{XSTBj}(14)$$

Increments due to J cards (J = 36) are then added to the above values.

4.17 STABILIZING SURFACE GROUPS

4.17.1 Surface No. 1 (Include only if IPL(1) $\leq$ 9 and IPL(16) $\neq$ 0)

CARD 151

Stabilizing surface area should include carry-through area if any.

Location of the center of pressure is the point of application of lift and drag forces used to determine moments about the aircraft center of gravity due to these forces.

XSTB1(5) is the incidence angle of the surface when all primary flight controls are at 50 percent and the control surface deflection is zero. If equations are being used, this angle should be the zero lift line angle; if tables are used, it should be chordline incidence. Positive incidence is a right-handed rotation about the positive axis of incidence change; e.g., for a horizontal surface, positive incidence is leading edge up.

The axis of incidence change is assumed to lie in the body Y-Z plane that contains the center of pressure of the surface, i.e., the plane at stationline XSTB1(2). The dihedral angle, XSTB1(6), is the angle in this Y-Z plane between the Y-axis (horizontal) and the axis of incidence change. At XSTB1(6) = 0, the positive axis of incidence change is parallel to the positive body Y-axis. If the surface is on the right side of the aircraft, the dihedral angle is positive for the right-hand, or outboard, tip up (i.e., if the cp buttline, XSTB1(3), is greater than zero, positive dihedral, XSTB1(6), is a left-handed rotation about an axis parallel to the positive body X-axis). If the surface is on the centerline or left side of the aircraft, the dihedral angle is positive for the left-hand, or outboard, tip up (i.e., if the cp buttline is equal to or less than zero, positive dihedral is a right-hand rotation about an axis parallel to the positive body X-axis). See Figure 29.

The sweepback angle of the quarter chord, XSTB1(7), is positive aft and lies in the plane formed by the axis of incidence change and the zero lift line.

CARD 152

Aspect ratio, spanwise efficiency factor, and taper ratio (XSTB1(8), (9), and (10), respectively) are identical to the corresponding wing inputs (XWG(8), (9), and (10), respectively).

The tailboom bending coefficient, XSTB1(11), reduces the lift coefficient on the surface by the formula

$$C_L' = C_L/[1 + XSTB1(11)*q_S*S_S*C_L/a]$$

where C_L = lift coefficient from subroutine CLCD

q_S = dynamic pressure at the surface

S_S = area of the surface

α = angle of attack of the surface (in radians)

C_L' = lift coefficient used for the surface

XSTB1(12) and XSTB1(13) are discussed in Section 4.17.2.

Positive control surface deflection, XSTB1(14), is defined in the same direction as positive zero lift line incidence, i.e., a right-handed rotation about the positive axis of incidence change. For a horizontal surface this corresponds to trailing edge down.

CARDS 153 and 154

The inputs for changing the lift, drag, and pitching moment of a stabilizing surface with control deflection are identical to those for the wing. See CARD 14B and 14C in Section 4.16.4, and substitute XSTB1 for XWG. See the following section for a discussion of XSTB1(24) through (28), which is on CARD 154.

4.17.2 Flow Field at the Stabilizers

Inputs XSTB1(12), (13), and (24) through (34) define the flow field at the surface in the following manner.

The free-stream velocity components at the stabilizing surface are the velocity components at the fuselage center of pressure in a reference system yawed through an angle σ_f and pitched through the angle ϵ_f, with respect to the body axes. These resulting velocity components are resolved into the body axis system and are multiplied by the dynamic pressure ratio factor $\sqrt{1-XSTB1(12)}$.

The wash angles at the surface due to the fuselage (σ_f and ε_f) are a function of the fuselage aerodynamic angles (θ_w and ψ_w), whether the fuselage aerodynamics are being represented by equations (IPL(29) = 0) or by a table (IPL(29) ≠0).

Given θ_w and ψ_w, the program uses XFS(12), XFS(13) and XFS(14) to determine if the fuselage is operating in the Nominal Angle region, the High Angle region, or the Phased Angle region.

If the fuselage is operating in the Nominal Angle region, then

$$\varepsilon_f = \varepsilon_L = [XSTB1(24)*DTR + 0.5*XSTB1(25)*\sin(2\theta_w) + 0.25*RTD*XSTB1(26)*\sin^2(2\theta_w)]$$

$$\sigma_f = \sigma_L = [XSTB1(27) + 0.25*RTD^2*XSTB1(28)*\sin^2(2\theta_w)]*0.5*\sin(2\psi_w)$$

where θ_w, ψ_w, ε_f and σ_f are in radians.

Note that the above equation can be approximated for small angles as

$$\varepsilon'_L = (XSTB1(24) + XSTB1(25)*\theta_w + XSTB1(26)*\theta_w^2)$$

$$\sigma'_L = (XSTB1(27) + XSTB1(28)*\theta_w^2)*\psi_w$$

where θ_w, ψ_w, ε'_L, and σ'_L are all in degrees.

If the fuselage is operating in the Phased region

$$\varepsilon_f = \varepsilon_L*\cos^2(\alpha_{ph})$$

$$\sigma_f = \sigma_L*\cos^2(\alpha_{ph})$$

where α_{ph} is the phasing angle defined in the fuselage discussion (Section 4.14).

If the fuselage is operating in the High Angle region, then

$$\varepsilon_f = \sigma_f = 0$$

If the wing group is included, downwash and dynamic pressure loss at the surface due to the wing will be computed as discussed in the Wing Group section. If the wing is excluded, these calculations will be bypassed, and the value of XSTB1(13) will be ignored.

Inputs XSTB1(29) through (34) control the effect of the rotor wake on the flow field at the surface. If XSTB1(29) and (32) are greater than 100, RWAS tables will be used to compute the effect in the same manner as is done for the wing (see CARD 145 in Section 4.16.1). In this case, XSTB1(30), (31), (33), and (34) are ignored. If both inputs are less than or equal to 100, the effect will be computed in a manner similar to that for the wing. The difference is that the two inputs following XSTB1(29) and (32) define the body axis X velocities at which the surface starts to enter the wake and is completely within the wake. See Figure 32. As with the wing, both effects must be represented by constants or both by tables.

4.17.3 Aerodynamic Inputs

See Section 4.16.2 for discussion of the aerodynamic computations.

4.17.4 Control Linkage Inputs (Include only if IPL(16) > 0)

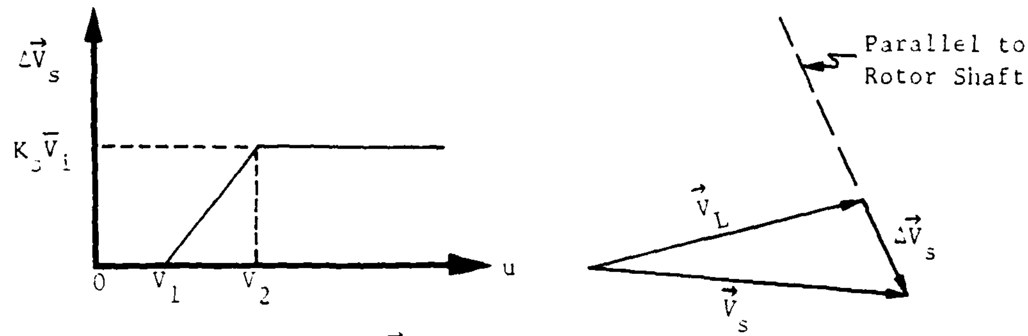
The stabilizing surfaces use a mathematical model and input format identical to that of the wing for linking the surface incidence or control surface deflection to the primary flight controls. See Section 4.16.4 and replace XCWG with XCS1 in that discussion.

4.17.5 Surface No. 2 (Include only if IPL(1) $\leq$ 9 and IPL(17) $\neq$ 0)

The mathematical model for Stabilizing Surface No. 2 is identical to that for Stabilizing Surface No. 1. Refer to Section 4.17.1 and substitute XSTB2 for XSTB1 in the discussion. Include the control linkage inputs (XCS2) only if IPL(17) > 0.

4.17.6 Surface No. 3 (Include only if IPL(1) $\leq$ 9 and IPL(18) $\neq$ 0)

The mathematical model for Stabilizing Surface No. 3 is identical to that for Stabilizing Surface No. 1. Refer to Section



(a) Computation of $\Delta\vec{V}_s$ (b) Local Flow with Downwash

$\vec{V}_L$ = local velocity vector at stabilizer excluding rotor downwash

$\Delta\vec{V}_s$ = change in $\vec{V}_L$ due to rotor wake

$\vec{V}_s$ = $\vec{V}_L + \Delta\vec{V}_s$

$\overline{V}_i$ = average induced velocity across the rotor disc, parallel to the rotor shaft

u = body X axis component of flight path velocity V

K_s = XSTB1(29), main rotor induced velocity factor

V_1 = XSTB1(30), the u velocity at which the stabilizer enters the rotor downwash

V_2 = XSTB1(31), the u velocity at which the stabilizer is completely immersed in rotor downwash

<u>NOTE</u>: V_1 must not be greater than V_2. Although it is permissible for V_1 to equal V_2, this is actually a contradiction: the surface cannot start to enter and be completely immersed in the downwash at the same velocity. Hence, if $V_1 = V_2$, the following definition applies:

$$\left|\Delta\vec{V}_s\right| = \begin{cases} 0.0 \text{ if } u \leq V_2 \\ K_s\,\overline{V}_i \text{ if } u > V_2 \end{cases}$$

Figure 32. Effect of Rotor Downwash on the Flow Field at the Stabilizing Surfaces.

4.17.1 and substitute XSTB3 for XSTB1 in the discussion. Include the control linkage inputs (XCS3) only if IPL(18) > 0.

4.17.7 <u>Surface No. 4 (Include only if IPL(1) $\leq$ 9 and IPL(19) $\neq$ 0)</u>

The mathematical model for Stabilizing Surface No. 4 is identical to that for Stabilizing Surface No. 1. Refer to Section 4.17.1 and substitute XSTB4 for XSTB1 in the discussion. Include the control linkage inputs (XCS4) only if IPL(19) > 0.

4.18 JET GROUP (Omit entire group if IPL(1) > 9 or IPL(20) = 0)

CARD 191

The number of controllable jets, XJET(1), defines which of the two jet thrusts can be linked to the flight controls. If XJET(1) = 0.0, neither jet can be controlled. In this case all four jet control linkages in the Controls Group (i.e., XCON(6), XCON(13), XCON(20), and XCON(27) described in Section 4.20) must be zero. If they are not, program execution will terminate during initialization.

If XJET(1) = 1.0, only the right (first) jet thrust, XJET(2), can be changed by control motion. If XJET(1) = 2.0, both jet thrusts can be changed by control motion. During maneuvers either jet thrust may be changed independently of the value of XJET(1) and the control linkages, as discussed in Section 4.20. The location of the right jet is the point of application of its thrust. The left (second) jet is located at the same stationline and waterline as the right jet, but at Buttline -XJET(5). It is not necessary that the right (first) jet be located on the right side of the rotorcraft. However, it will be labeled in the output as the right jet regardless of its location. Similarly, the left (second) jet buttline location is always -XJET(5) and will always be labeled as the left jet.

CARD 192

The jet thrust vectors are oriented with respect to the body reference system by a set of ordered rotations: yaw, then pitch. For the right jet, the rotations are right-handed, while for the left jet they are left-handed. Hence both the location and orientation of the two thrust vectors are symmetrical about the body X-Z plane.

For XJET(2) and XJET(3) positive and XJET(8) = XJET(9) = 0.0, both vectors are parallel to the body X-axis and cause positive (forward) forces in the body reference system. A positive yaw angle will then cause a right (positive) body Y-force from the right jet and a left (negative) body Y-force from the left jet. Positive pitch angle will cause an upward (negative) body Z-force from both jets.

4.19 EXTERNAL STORE/AERODYNAMIC BRAKE GROUP (Omit entire group if IPL(1) > 9 or IPL(21) = 0)

This group consists of exactly IPL(21) Store/Brake subgroups. The sequence number of the subgroup is the same as the input sequence. Each subgroup uses the same input format and mathematical model. A single subgroup is intended to represent a single store/brake, and all subgroups are mutually independent.

4.19.1 Store/Brake No. 1 (Include only if IPL(21) ≥ 1)

CARD 201A

The weight input, XST1(1), defines how the subgroup is to be used. This weight must not be included in the aircraft gross weight, XFS(1). If XST1(1) = 0, all calculations for this subgroup are bypassed.

If XST1(1) > 0, the subgroup is defined to be an external store, and the following applies: prior to starting the TRIM procedure, the store weight and inertias (XST1(1) and XST1(8) through XST1(11)) are added to the weight and appropriate inertial inputs in the Fuselage Group, XFS(1) and XFS(8) through XFS(11). The aircraft cg and inertias are then recalculated for each external store subgroup. When a store is dropped in the maneuver section, the aircraft weight, cg, and inertias are recalculated to reflect the jettison. Note that when using the sweep option (NPART = 10), the baseline values of aircraft weight, cg, and inertias, XFS(1) and XFS(5) through XFS(11), change only when changed by NAMELIST inputs. The recalculated values are never carried forward to subsequent cases. Consequently, the recalculation procedure is performed at the start of each and every case in the sweep using the current values of baseline and store weight, cg, and inertias, i.e., XFS(1), XFS(5) through XFS(11), XST1(1) through XST1(4), and XST1(8) through XST1(11).

If XST1(1) < 0, the subgroup is defined to be an aerodynamic brake. A brake is assumed to be an integral part of the airframe with its weight and inertias included in the inputs to the Fuselage Group. Aircraft weight, cg, and inertias are not recalculated.

In the maneuver section, only store subgroups can be dropped (J = 35), and only brake subgroups can be deployed (J = 34). J-Card inputs which command otherwise (i.e., drop a brake or deploy a store) will cause program execution to terminate.

The aerodynamic forces of both stores and brakes act at the center of pressure. The cp is assumed to be at the same buttline and waterline as the store/brake cg. The cp stationline is calculated by

$$(SL)_{cp} = XST1(2) + XST1(5) + XST1(6)*\sin^2\alpha_{sc}$$

The dynamic pressure loss ratio, XST1(7), is the ratio of local dynamic pressure loss at the store/brake to free-stream dynamic pressure, neglecting rotor downwash. An input of zero indicates that the total free-stream dynamic pressure acts at the store/brake.

CARD 201B

The store inertias are those of the store about its own cg, in the fuselage body axis coordinate system, and are not to be included in the inertias in the Fuselage Group. If the store inertias are given in the store axis system, they must be resolved into the fuselage body axis system before input to C81.

The induced velocity factor is the fraction of the induced velocity at the rotor disc which acts at the store/brake cp. With no interference and a fully developed downwash, this factor would theoretically be 2.0. In practice, it would be less than 2.0 due to interference effects, nonuniform downwash, and the rotor wake not being fully contracted.

The lift, drag, and side forces calculated are each multiplied by XST1(14)/100 to simulate aerodynamic brake deployment. If XST1(1) indicates that a store is to be simulated, XST1(14) is reset to 100 percent.

CARD 181C

The wind axis aerodynamic forces on the store/brake are calculated from the following equations. These forces are separate aerodynamic forces and are not included in the forces generated by any other component of the aircraft.

$$\text{Lift} = q_s\ [XST1(15)*\cos\psi_s + XST1(16)*\sin(2r_s)*\cos\psi_s]$$

$$\text{Drag} = q_s\ [XST1(17)*(\cos^2\psi_s)*(\cos^2\theta_s) + XST1(18)*\sin^2\psi_s$$
$$+ XST1(19)*(\cos^2\psi_s)*(\sin^2\theta_s)]$$

$$\text{Side Force} = q_s\ [XST1(20)*\cos^2\theta_s + XST1(21)*\sin(2\psi_s)*\cos^2\theta_s]$$

where $V_s = \sqrt{1-XST1(7)} * V_{free\ stream} + XST1(12)*(\bar{V}_i)_{R_1}$

$$+ XST1(13)*(\bar{V}_i)_{R_2}$$

$$q_s = 0.5\rho*V_s^{2}*XST1(14)/100$$

$$\theta_s = \tan^{-1}(w_s/u_s)$$

$$\psi_s = -\sin^{-1}(v_s/V_s)$$

$$\alpha_{sc} = \cos^{-1}(u_s/V_s)$$

u_s = body axis x component of V_s at store/brake

v_s = body axis y component of V_s at store/brake

w_s = body axis z component of V_s at store/brake

$\bar{V}_i$ = average induced velocity at disc of specified rotor

4.19.2 Store/Brake No. 2 (Include only if IPL(21) > 2)

CARDS 202A, 202B, and 202C contain the inputs for Store/Brake No. 2. Refer to the section on Store/Brake No. 1, and substitute XST2(I) for XST1(I).

4.19.3 Store/Brake No. 3 (Include only if IPL(21) > 3)

CARDS 203A, 203B, and 203C contain the inputs for Store/Brake No. 3. Refer to the section on Store/Brake No. 1, and substitute XST3(I) for XST1(I).

4.19.4 Store/Brake No. 4 (Include only if IPL(21) = 4)

CARDS 204A, 204B, and 204C contain the inputs for Store/Brake No. 4. Refer to the section on Store/Brake No. 1, and substitute XST4(I) for XST1(I).

4.20 ROTOR CONTROLS GROUP

The Controls Group is divided into two subgroups: Basic and Supplemental. The Basic Rotor Controls subgroup is a required input. The reading of the Supplemental Rotor Controls subgroup is controlled by IPL(22). This optional subgroup is only a necessary input for tandem and side-by-side rotor configurations although it can also be used to simulate very complex control systems for single main rotor helicopters. Figure 33 is a schematic of the complete AGAP80 rotor control system. The Controls Group defines the linkages between the pilot controls and rotors for a rigid pylon, no collective bob-weight, and SCAS off, i.e., the blocks labeled "BASIC RIGGING", "NONLINEAR RIGGING", and "CONTROL COUPLING/MIXING BOX" in Figure 33. The outputs of the rotor controls mathematical model are the root collective blade angle and swashplate angles of each rotor.

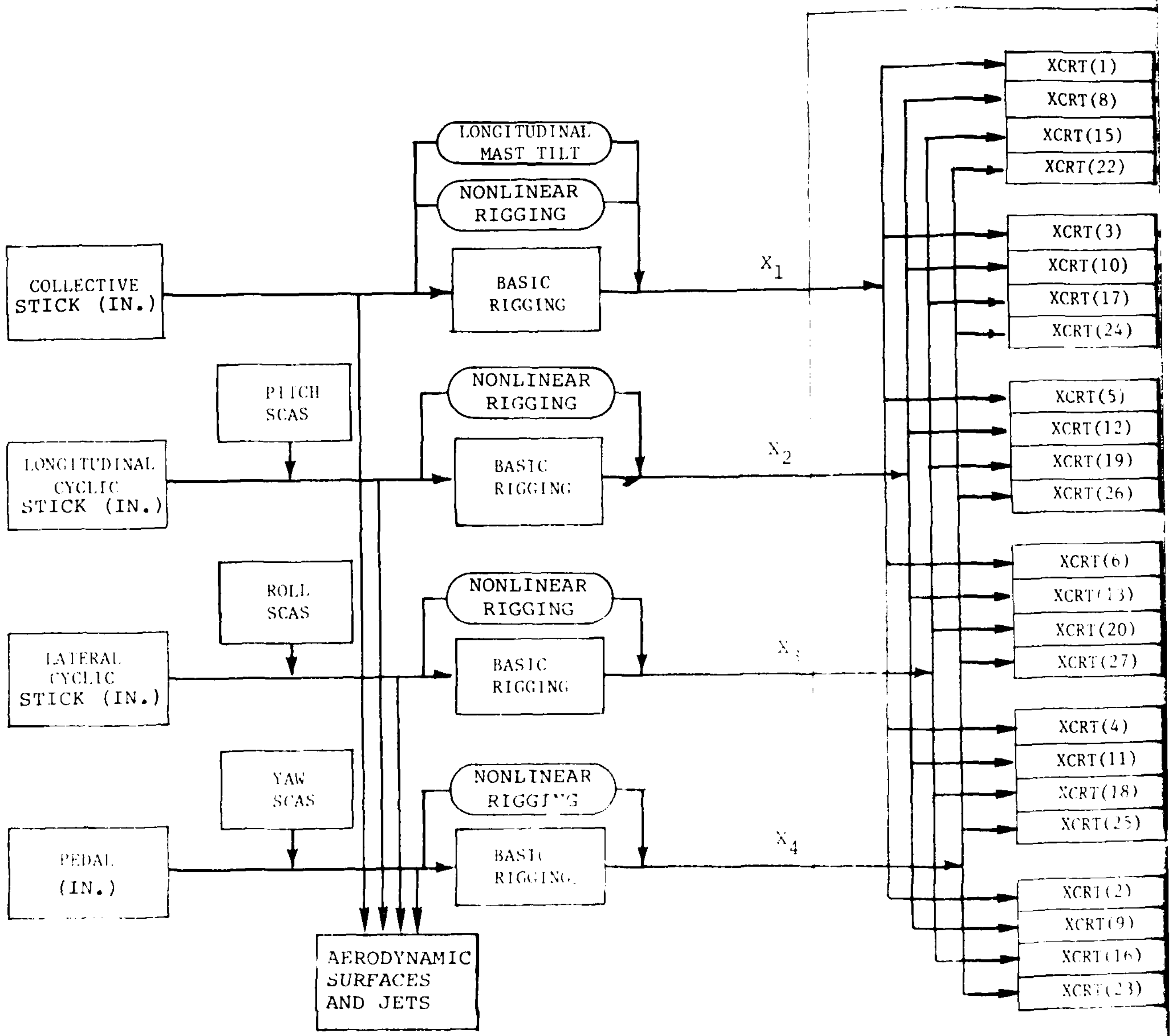
The models for the rotor controls, pylon coupling, bobweight, and SCAS are mutually independent. That is, the value of any output of any one model does not affect the value of the outputs of any other model. The outputs of the last three models are treated as increments which are added to the appropriate output of the rotor controls model.

4.20.1 Basic Rotor Controls Subgroup

The inputs on CARDS 211 through 214 are termed the Basic Rotor Control, or XCON, inputs. These inputs define the basic linkages between each of the four primary flight controls (collective, longitudinal cyclic, lateral cyclic, and pedal) and the rotor control angles. All linkages are linear and uncoupled and are normally the only Rotor Controls Group inputs needed for a single-main-rotor helicopter. With these linkages, the collective stick controls the root collective pitch (as measured at the center of rotation) of Rotor 1, and the pedals control only the root collective pitch of Rotor 2.

If XCON(14) = 0.0 and XCON(21) = 270.0 (the default values), then longitudinal cyclic stick motion will yield longitudinal swashplate tilt, and lateral cyclic stick motion will give a lateral swashplate tilt. Fixed system control phasing will occur if XCON(14) $\neq$ 0.0 and XCON(21) $\neq$ 270.0, and the swashplate longitudinal and lateral rotational axes will not be perpendicular if XCON(14) and XCON(21) are not 90 degrees apart.

The cyclic pitch for Rotor 2 is defined to be zero when using just the Basic Rotor Controls (IPL(22) = 0).



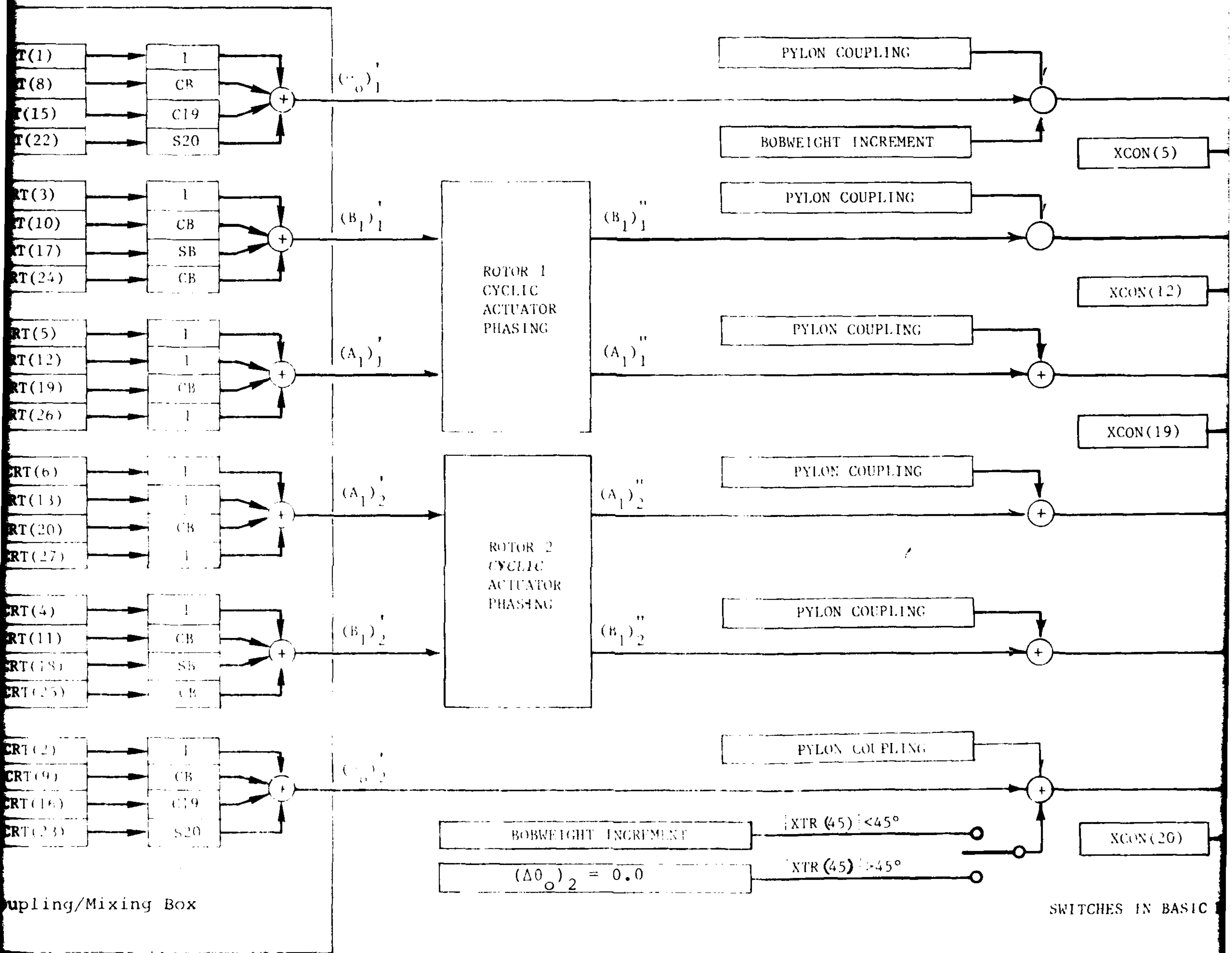
Control Coupling/

Definitions

CB = cos δ_M C19 = c

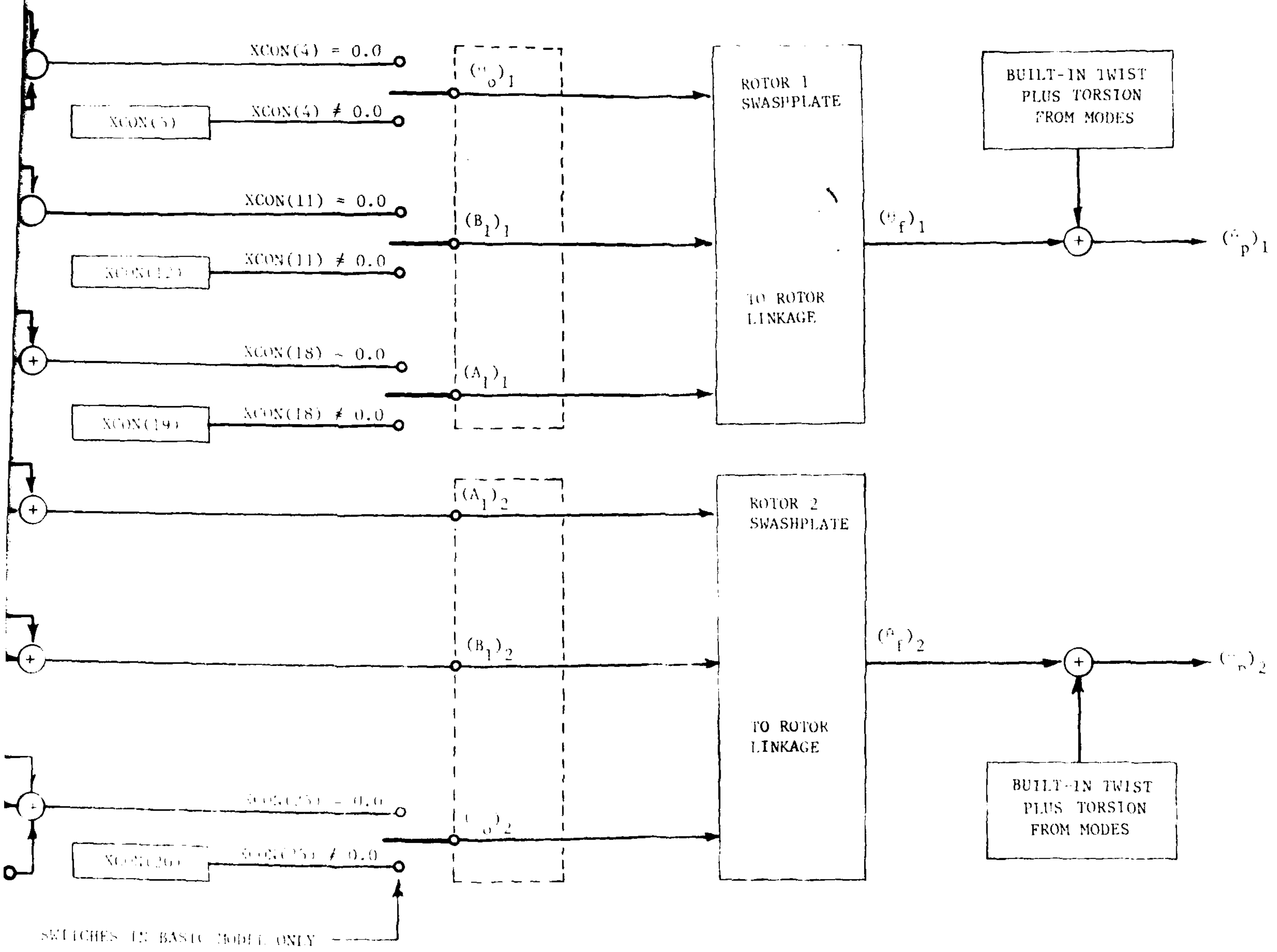
SB = sin δ_M S19 = s

Figure 33. Schematic of Rotor Control System.



C19 = cos(XCRT(19)*ψ_M)

S19 = sin(XCRT(20)*ψ_M + XCRT(21))



XCON(4) = 0.0
XCON(4) ≠ 0.0
XCON(11) = 0.0
XCON(11) ≠ 0.0
XCON(18) = 0.0
XCON(18) ≠ 0.0
XCON(19)
$(B_1)_1$
$(A_1)_1$
$(A_1)_2$
$(B_1)_2$
ROTOR 1 SWASHPLATE
TO ROTOR LINKAGE
ROTOR 2 SWASHPLATE
TO ROTOR LINKAGE
BUILT-IN TWIST PLUS TORSION FROM MODES
BUILT-IN TWIST PLUS TORSION FROM MODES

The equations for the control angles computed from the XCON inputs are given in Table 17. Note that the fourth input on each of the four cards can be used to lock the appropriate control angle at the value of the fifth input on the same card.

The sixth input on each of the four basic control cards is the linkage between the specified control and jet thrust. The equations for the individual increments to the jet thrust and the total jet thrust are also given in Table 17. The jet to which the controls are linked is a function of XJET(1) in the Jet Group. Also, the increment to jet thrust is proportional to the difference between the control position input to the Flight Constants Group and the current control position during the trim iterations or maneuver time history. That is, the change in jet thrust is proportional to a change in control position, not to the absolute value of that control position.

4.20.2 Supplemental Rotor Controls Subgroup (XCRT(1-49), omit if IPL(22) = 0)

The inputs to this subgroup are primarily intended to provide control linkages used in configurations other than single main rotor helicopters, e.g., tandem or side-by-side rotor helicopters and tilt rotor or composite aircraft. If the program decides that the configuration is not a single-main-rotor helicopter (KONFIG $\neq$ 1, see Section 4.30), an error message will be generated if XCRT inputs are not included.

The linkages defined in the Basic Controls subgroup are a subset of the complete rotor control system model shown in Figure 33. To use the complete model, both the Basic and Supplemental Rotor Controls subgroups must be input.

In the Basic Controls Subgroup discussed in the previous section, each primary flight control is linked linearly to a single blade or swashplate angle. In the complete model described below, each control is linked to the fixed-system intermediate control angles. The linkage may be linear, parabolic, or cubic, and in the case of the collective stick the linkage can be a function of the longitudinal mast tilt angle of Rotor 1. Then each fixed-system intermediate control angle can be linked to the collective or swashplate angles of either rotor. These linkages are linear but some can be functions of the longitudinal mast tilt angle of Rotor 1.

TABLE 17. BASIC ROTOR CONTROL RIGGING

$$\text{Rotor 1}\begin{cases}(\theta_o)_1 = \begin{cases}XCON(2) + XCON(3)*\delta_{COLL}/100 & \text{if } XCON(4) = 0\\ XCON(5) & \text{if } XCON(4) \neq 0\end{cases}\\ (B_1)_1 = (A_1)'_1*\cos(XCON(21)) + (B_1)'_1*\cos(XCON(14))\\ (A_1)_1 = -(A_1)'_1*\sin(XCON(21)) - (B_1)'_1*\sin(XCON(14))\end{cases}$$

where

$$(B_1)'_1 = \begin{cases}XCON(9) + XCON(10)*\delta_{LONG}/100 & \text{if } XCON(11) = 0\\ XCON(12) & \text{if } XCON(11) \neq 0\end{cases}$$

$$(A_1)'_1 = \begin{cases}XCON(16) + XCON(17)*\delta_{LAT}/100 & \text{if } XCON(18) = 0\\ XCON(19) & \text{if } XCON(18) \neq 0\end{cases}$$

$$\text{Rotor 2}\quad (\theta_o)_2 = \begin{cases}XCON(23) + XCON(24)*\delta_{PED}/100 & \text{if } XCON(25) = 0\\ XCON(26) & \text{if } XCON(25) \neq 0\end{cases}$$

$$\text{Jets}\begin{cases}(\Delta T_{JET})_1 = XCON(6)*XCON(1)*[\delta_{COLL} - XVC(8)]/100\\ (\Delta T_{JET})_2 = XCON(13)*XCON(8)*[\delta_{LONG} - XVC(9)]/100\\ (\Delta T_{JET})_3 = XCON(20)*XCON(15)[\delta_{LAT} - XVC(10)]/100\\ (\Delta T_{JET})_4 = XCON(27)*XCON(22)\ [\delta_{PED} - XVC(11)]/100\end{cases}$$

$$T_{JET} = (T_{JET})_{INPUT} + \sum_{i=1}^{4} (\Delta T_{JET})_i$$

δ_{COLL} = Collective stick position, in percent, from full down

δ_{LONG} = Longitudinal cyclic stick position, in percent, from full aft

δ_{LAT} = Lateral cyclic stick position, in percent, from full left

δ_{PED} = Pedal position, in percent, from full right

XVC(8) = Input value of δ_{COLL} (%) XVC(10) = Input value of δ_{LAT} (%)

XVC(9) = Input value of δ_{LONG} (%) XVC(11) = Input value of δ_{PED} (%)

$(T_{JET})_{INPUT}$ = Thrust of controllable jet(s), XJET(2) and/or XJET(3)

The fixed-system intermediate control angles, X_1 through X_4, are defined in Table 18. The effects of longitudinal mast tilt on X_1, the fixed-system collective intermediate control angle, are controlled by XCRT(29) through XCRT(32) on CARD 219. DTMIN is the change in minimum value of fixed-system collective angle due to mast tilt, while DTRNG is the change in the range of the input.

The control coupling ratios, input on CARDS 215 through 218, give the user the capability to control the cyclic swashplate angles of Rotor 2. In addition, fixed-system control phasing can be introduced through control coupling. If the Rotor 1 phasing is done in this manner, then XCON(14) and XCON(21) should be input as 0.0 and 270.0. Likewise, if the phasing for Rotor 2 is done by control coupling, then XCRT(43) and XCRT(44) (which are the analogues to XCON(14) and XCON(21) for Rotor 2) should be input as 0.0 and 270.0. All control coupling operations are performed in the Control Coupling/Mixing Box, Figure 33. The effects of Rotor 1 longitudinal mast tilt are also accounted for by the logic diagrammed in this box.

The outputs from the Control Coupling/Mixing Box are the collective intermediate control angle and the cyclic intermediate control angles for both rotors, $(\theta_o)_i^{\prime}$, $(B_1)_i^{\prime}$, and $(A_1)_i^{\prime}$, $i = 1$ or 2. The cyclic intermediate control angles are phased according to the cyclic actuator phasing angles, XCON(14), XCON(21), XCRT(43), and XCRT(44), and the increments to all six intermediate control angles due to pylon coupling are added to give the six fixed swashplate control angles, $(\theta_o)_i$, $(A_1)_i$, and $(B_1)_i$, $i=1$ or 2. The two collective angles are passed through to the rotating system, while the cyclic swashplate angles are commutated to get the cyclic control angles in the rotating system.

The blade root pitch angle for each rotor, measured at the center of rotation, is computed from the rotating swashplate components, γ and δ_3 for that rotor.

Default values for the Controls Group are given in Table 19.

TABLE 18. FIXED-SYSTEM INTERMEDIATE CONTROL ANGLES

Collective

$$X_1 = [XCON(2) + DTMIN] + [XCON(3) + DTRNG]*\delta_{COLL}/100 + XCRT(36)*K_1^2$$

Longitudinal Cyclic

$$X_2 = XCON(9) + XCON(10)*\delta_{LONG}/100 + (\Delta X_2)_{SCAS} + XCRT(37)*K_2^2 + XCRT(38)*K_2^3$$

Lateral Cyclic

$$X_3 = XCON(16) + XCON(17)*\delta_{LAT}/100 + (\Delta X_3)_{SCAS} + XCRT(39)*K_3^2 + XCRT(40)*K_3^3$$

Pedal

$$X_4 = XCON(23) + XCON(24)*\delta_{PED}/100 + (\Delta X_4)_{SCAS} + XCRT(41)*K_4^2 + XCRT(42)*K_4^3$$

$$\left.\begin{aligned} K_1 &= (\delta_{COLL} - 50)*XCON(1)/100 \\ K_2 &= (\delta_{LONG} - 50)*XCON(8)/100 \\ K_3 &= (\delta_{LAT} - 50)*XCON(15)/100 \\ K_4 &= (\delta_{PED} - 50)*XCON(22)/100 \end{aligned}\right\} \quad \text{Control deflections in inches from the 50\% position}$$

$$DTMIN = \begin{cases} XCRT(30)*\beta_m + XCRT(31)*\beta_m^2 & XCRT(29) \neq 0.0 \\ 0.0 & XCRT(29) = 0.0 \end{cases}$$

$$DTRNG = \begin{cases} [XCRT(32) - XCON(3)]*\beta_m/(\pi/2) & XCRT(29) \neq 0.0 \\ 0.0 & XCRT(29) = 0.0 \end{cases}$$

β_m = Longitudinal mast tilt angle of Rotor 1, degrees

$(\Delta X_2)_{SCAS}$ = Change in longitudinal cyclic input due to SCAS

$(\Delta X_3)_{SCAS}$ = Change in lateral cyclic input due to SCAS

$(\Delta X_4)_{SCAS}$ = Change in pedal input due to SCAS

TABLE 19. CONTROL INPUT DEFAULTS

Input	Default Value
XCON(1)	100.0 inches
XCON(3)	100.0°
XCON(8)	100.0 inches
XCON(9)	-50.0°
XCON(10)	100.0°
XCON(15)	100.0 inches
XCON(16)	-50.0°
XCON(17)	100.0°
XCON(22)	100.0 inches
XCON(23)	-50.0°
XCON(24)	100.0°
XCRT(1)	1.0
XCRT(10)	1.0
XCRT(19)	1.0
XCRT(23)	1.0
XCRT(32)	100.0°

4.21 ITERATION LOGIC GROUP

CARD 221

The program is permitted up to XIT(1) iterations to converge to a trimmed flight condition. If the force and moment summations are not less than the allowable errors, XIT(50) through XIT(53) and XIT(57) through XIT(63), execution terminates.

If the time-variant trim option is activated (IPL(49)$\neq$0), the increment between the rotor azimuth angles used in the analysis may be input as XIT(2). If the input is 0.0, XIT(2) is reset to 30.0 degrees. If the input is not zero, the program examines the natural frequencies of the modes of both rotors. It then checks that the current value of XIT(2) will provide at least 10 points for each cycle of the highest frequency present and, if necessary, resets XIT(2) to satisfy this condition. The value of XIT(2) is then checked to see if it is less than 2.0 degrees or greater than 30.0 degrees. If it is, XIT(2) is then reset to the nearer value. If either of the unsteady aerodynamic options is activated (IPL(48) $\neq$ 0), XIT(2) should be less than 10 degrees for the numerical differentiation to work properly. See Section 4.28 for additional discussion of azimuth increments.

XIT(3) is the induced velocity change limiter. It is equal to half the maximum amount the induced velocity is allowed to change within iterations in TRIM and between time points in maneuver. Three thrust-induced velocity iterations are made within each trim iteration in the TRIM portion of the program. The sign of XIT(3) controls the application of the limit in these thrust-induced velocity iterations. If XIT(3) > 0, the limit is applied to the first and third passes through this loop. If XIT(3) < 0, the limit is applied to all three passes. If XIT(3) = 0, it is reset to 0.5 ft/sec. Note that the input sign of XIT(3) controls only the manner in which the limit is applied. The sign of the increment applied within the program is determined by the program. This option allows the user to better regulate the numerical bounce problem sometimes encountered when performing a TRIM.

XIT(4) is a nondimensional factor used to compute the increments to the linear and angular velocities to be used in the STAB subroutine. The angular rate increments are 0.10 radian per second times the input, and the linear rate increments are 10 feet per second times the input.

Time-history plots of variables listed in Section 9 may be made after trim if either rotor is time-variant and 0 < XIT(5) $\leq$ XIT(6). In this case, data for the last XIT(5) revolutions will be passed to GDAP80 for postprocessing.

XIT(6) is used to control the number of complete rotor revolutions computed in the time-variant rotor analysis, both in the normal TVT following a QS trim and in the rotor analysis in the fully-time-variant trim. If XIT(6) is input as 0.0, the defaults are 5.0 revolutions in TVT and 3.0 in FTVT. For soft-inplane rotors it has been found that the default value of 5 revolutions in TVT is usually not enough to achieve a periodic solution; 10 to 15 revolutions may be required, depending on the damping present.

XIT(7) controls a numerical damping procedure to assist in finding QS trim conditions for elastic rotors with torsion in the mode shapes. The input should always be between 0.0 and 1.0. An input of 1.0 would provide no damping (0.0 defaults to 0.3). An input of 0.5 gives a simple averaging procedure. The default value (0.3) seems to be the best choice in most cases. Smaller inputs have been used, but they may slow the trim convergence.

Default values for these inputs are given in Table 20.

CARDS 222 through 227

As described in the discussion of the trim procedure, each component of the correction vector has a maximum absolute value which it is not allowed to exceed. This maximum absolute value is a variable determined by the variable damper logic. The starting value for each maximum allowed absolute value is input on CARDs 222 and 223. Whenever the absolute value of the trim imbalance for a particular constraint equation is less than the corresponding variable damper activation value input on CARDs 226 and 227, the maximum allowed correction limit is divided by two. This division process occurs every time the absolute value of the trim imbalance is less than the variable damper activation value, or until the correction limit is less than or equal to the corresponding minimum value of the correction limit, as input on CARDs 224 and 225. (If the correction limit is less than the minimum value, it is reset to the minimum value).

Default values for the variable damper inputs are given in Table 20.

CARDs 228 and 229

The trim procedure will cease iterating and print a trim page after XIT(1) iterations or whenever the absolute value of each of the trim imbalances is less than, or equal to, the corresponding allowable error input on CARDs 228 and 229. In the latter case, the rotorcraft is then trimmed to the desired

TABLE 20. DEFAULT VALUES FOR THOSE ITERATION LOGIC GROUP INPUTS THAT HAVE DEFAULTS

XIT(2)	4° $\leq$ 10 points/cycle for the highest frequency rotor elastic mode $\leq$ 30°
XIT(3)	0.5 ft/s
XIT(4)	0.5
XIT(5)	1.0
XIT(6)	5.0 TVT 3.0 FTVT
XIT(7)	0.3
XIT(8) through XIT(13), XIT(15) through XIT(19)	<0.25° or >5.0° reset to 0.5
XIT(20)	50.0 ft/s
XIT(22) through XIT(27), XIT(29) through XIT(33)	<0.05° reset to 0.1° >1.0° reset to 1.0°
XIT(34)	0.5 ft/s
XIT(36) through XIT(48)	Maximum (input, 40*XIT(57)) unless one or both rotors are decoupled; then the appropriate value of XIT is replaced by the maximum (input, 40*XIT(I)) where I is 51, 52, 53 or 54.
XIT(49)	600.0 HP
XIT(50) through XIT(63)	No default unless IPL(1) = 11, in which case XIT(52) through XIT(63) are reset to 10^{20}.
XIT(71)	3.0

Note: These are no default values for XIT(12), XIT(13) and XIT(15) through XIT(19). XIT(2) will be reset appropriately to satisfy the Range-Kutta stability criterion if a rotor is to be analyzed using the time-variant procedure. See the description of XIT(2), which applies only during trim.

flight condition to within the following acceleration imbalances:

$$\left|\ddot{a}_{1_{\text{Rotor 1}}}\right| \le \text{XIT(50)}/I_{\text{Flap}_{\text{Rotor 1}}}$$

$$\left|\ddot{b}_{1_{\text{Rotor 1}}}\right| \le \text{XIT(51)}/I_{\text{Flap}_{\text{Rotor 1}}}$$

$$\left|\ddot{a}_{1_{\text{Rotor 2}}}\right| \le \text{XIT(52)}/I_{\text{Flap}_{\text{Rotor 2}}}$$

$$\left|\ddot{b}_{1_{\text{Rotor 2}}}\right| \le \text{XIT(53)}/I_{\text{Flap}_{\text{Rotor 2}}}$$

$$\left|\ddot{X}_{cg}\right| \le \text{XIT(57)}/M_a$$

$$\left|\ddot{Y}_{cg}\right| \le \text{XIT(58)}/M_a$$

$$\left|\ddot{Z}_{cg}\right| \le \text{XIT(59)}/M_a$$

$$\left|\ddot{\psi}_{cg}\right| \le \text{XIT(60)}/I_{yaw}$$

$$\left|\ddot{\theta}_{cg}\right| \le \text{XIT(61)}/I_{pitch}$$

$$\left|\ddot{\phi}_{cg}\right| \le \text{XIT(62)}/I_{roll}$$

where I_{flap} is the flapping inertia of the rotor

M_a is the total mass of the aircraft, including stores

I_{yaw}, I_{pitch}, I_{roll} are the angular inertias of the entire aircraft including stores, about the aircraft center of mass.

The flapping inertia is a function of the number of blades, b, and the individual blade flapping inertia, I_β, which is either input as XMR(12) (XTR(12)) or determined from the mass distribution input with the rotor elastic mode shapes. For a one- or two-bladed rotor,

$$I_{flap} = b\ I_{\beta}$$

For rotors with more than two blades,

$$I_{flap} = \frac{b}{2}\ I_{\beta}$$

If one of the rotors is deleted from the analysis, the corresponding allowable flapping moment errors should be set to very large numbers.

Default values for the allowable error inputs are described in Table 20.

CARD 22A

If a steady-state maneuver is being simulated in the TRIM portion of the program (IPL(1) = 2 or 3), the desired g-level is XIT(66), in feet per second per second. The program will then try to trim to a normal load factor, n:

$$n = 1 + XIT(66)/32.1725$$

In addition, for banked turns (IPL(1) = 3), the program will iterate on pitch and yaw, regardless of the TRIM procedure specified by IPL(44). The "fixed" roll angle for each iteration is determined from the previous iteration by solving the following relationship for roll angle:

$$n*\cos\phi = \cos\theta*\cos^2\phi + (\cos\phi*\sin^2\phi + \tan\beta*\sin\phi*\sin\theta)/K$$

where

$K = 1 + (\tan\theta\tan\alpha)/\cos\phi$

θ = Euler pitch angle

ϕ = Euler roll angle

n = normal load factor

α = angle of attack

β = angle of sideslip

The turn direction is selected by use of the sign on the input roll angle, XFC(7). A positive or zero value gives a right turn, a negative value a left turn.

If IPL(1) equals 6 or 7, the program also trims to a desired horsepower, plus or minus the allowable error on horsepower, i.e.,

$$|HP_{computed} - XIT(70)| \leq XIT(63)$$

CARD 22B

The control increments used for computing the derivatives in the STAB analysis are

$$\Delta_{Collective} = XIT(71)*XIT(26)$$

$$\Delta_{Long.\ Cyclic} = XIT(71)*XIT(27)$$

$$\Delta_{Lat\ Cyclic} = XIT(71)*XIT(29)$$

$$\Delta_{Pedal} = XIT(71)*XIT(30)$$

XIT(71) defaults to 3.0.

4.22 FLIGHT CONSTANTS GROUP

CARD 231

The input velocities are with respect to the ground. The forward velocity is not necessarily the total velocity.

The altitude input is the height above the ground. It is used in the calculations for ground effect and the landing gear forces, and locates the helicopter with respect to a trailing vortex pair, if used (see J=37, Section 4.29.2.28). If the input altitude is negative, the program stops. This input has no relationship to the pressure altitude, XFC(27), on CARD 234.

The Euler angles are the angles from the ground reference system to the body reference system. Yaw is positive nose right; pitch is positive nose up; roll is positive down right.

CARD 232

The collective and cyclic stick and pedal positions are the initial settings with which the program begins its TRIM iterations.

CARD 233

The flapping angle and rotor thrust inputs are used as initial values in the TRIM iteration procedure.

CARD 234

XFC(26), the atmospheric logic switch, is used in conjunction with the pressure altitude, XFC(27), and ambient temperature, XFC(28), to compute the density ratio, σ'; density altitude, h_D; and speed of sound, V_S. If XFC(26) = 0, standard-day conditions are assumed, XFC(28) is ignored, and the parameters are calculated from the following equations:

$$\theta_S = 1 - (0.687535 \times 10^{-5})*XFC(27)$$

$$T_A = 288.16\ \theta_S - 273.16$$

$$\sigma' = (\theta_S)^{4.2561}$$

$$V_s = 65.811366\ \sqrt{T_A + 273.16}$$

$$h_D = XFC(27)$$

If XFC(26) $\neq$ 0, nonstandard-day conditions are assumed. If XFC(26) > 0, the ambient temperature is defined to be in degrees Fahrenheit and

$$T_A = 5[XFC(28) - 32]/9$$

If XFC(26) < 0, then XFC(28) is defined to be in degrees centigrade and

$$T_A = XFC(28)$$

Then

$$\delta = (\theta_S)^{5.2561}$$

$$\theta = (T_A + 273.16)/288.16$$

$$\sigma' = \delta/\theta$$

$$V_s = 65.811366\ \sqrt{T_A + 273.16}$$

$$h_D = (1 - (\sigma')^{0.23496})/(0.687535 \times 10^{-5})$$

If XFC(26) $\geq$ 100.0, then XFC(27) and (28) are defined to be the density ratio and speed of sound, respectively:

σ' = XFC(27) (dimensionless)

V_s = XFC(28) (ft/sec)

and the pressure and density altitudes and ambient temperatures are computed within the program based on the preceding equations.

NOTE: For TRIM or TRIM-STAB input decks (NPART = 1 or 7), the only cards which may follow CARD 234 are those of a parameter sweep (NPART = 10) and GDAP80 postprocessing cards.

4.23 <u>BOBWEIGHT GROUP</u> (Include only if NPART = 2 or 4 and <u>IPL(23) ≠ 0)</u>

CARD 241

For no bobweight, set XBW(1) = 0.

If XBW(1) ≠ 0, the following bobweight model is used.

The bobweight system acts to reduce collective pitch with increasing load factor during maneuvers. The system is assumed to be mounted so that the weight is free to translate only parallel to the body vertical, or Z, axis. The equation of motion for the weight in the system is

$$\frac{1}{12} m\ddot{\delta} + C\dot{\delta} + K\delta = F_{BW}$$

where

δ = the linear displacement of the bobweight from its position at 1.0 g, positive down (in.)

$\dot{\delta}$ = linear velocity (in./sec)

$\ddot{\delta}$ = linear acceleration (in./sec^2)

F_{BW} = bobweight forcing function described below (lb)

K = XBW(2), the spring constant (lb/in.)

C = XBW(3), the damping coefficient (lb-sec/in.)

W = XBW(4), the weight of the bobweight (lb)

m = W/32.1725, the mass of the bobweight (slugs)

Other symbols used are

n_p = XBW(7), the system preload (g)

n = load factor (g)

$\Delta\theta_o$ = increment to collective pitch due to bobweight displacement (deg)

η = XBW(1), linkage of δ to $\Delta\theta_o$ (deg/in.)

The forcing function is defined as a function of W, n, and n_p at each time point during the maneuver. At time t = 0,

$$\ddot{\delta} = \dot{\delta} = \delta = 0.0$$

and

$$F_{BW} = \text{Max}\ [0,\ W(n-n_p)]$$

NOTE: The bobweight is not active during the trim procedure. Hence, if a maneuver is started from a trim where n is greater than n_p, collective stick position (and possibly other control positions if control coupling is present) will not be correct. Since maneuvers are normally started from 1.0 g flight and the preload is greater than 1.0, this should not create a problem.

At the first time point where n exceeds n_p, whether at or following the start of the maneuver, the forcing function is defined there and at subsequent time points as

$$F_{BW} = W(n-n_p)$$

That is, once n exceeds n_p, the forcing function can be negative if n later drops below n_p. This definition of F_{BW} applies as long as

$$\delta > 0.0 \text{ or } \ddot{\delta} \geq 0.0$$

at each subsequent time point.

If at any time point the computations yield $\delta \leq 0.0$ and $\ddot{\delta} < 0.0$, the bobweight parameters for the next time point are reinitialized to

$$\ddot{\delta} = \dot{\delta} = \delta = 0$$

and

$$F_{BW} = \text{Max}\ [0,\ W(n-n_p)]$$

i.e., the same values as at t = 0. Subsequent computations proceed as from t = 0.

The increment added to collective pitch is then

$$\Delta\theta_o = -\eta\delta$$

i.e., positive bobweight displacement and positive linkage reduces collective pitch. This increment is always added to the main rotor collective. If the lateral mast tilt angle for Rotor 2, XTR(45), is less than 45 degrees, the increment is also added to the Rotor 2 collective pitch.

4.24 WEAPONS GROUP (Include only if NPART = 2 or 4 and IPL(23) $\neq$ 0)

CARD 251

Stationline, buttline, and waterline are used to locate the point of application of the recoil force of the weapon.

Azimuth and elevation define the orientation of the weapon with respect to the fuselage. Positive azimuth is to the right; positive elevation is up. With both angles zero, the weapon is aligned parallel to the body X axis and is defined to be firing in the positive X-direction (forward).

The recoil force is prescribed on a 301-type card. See Section 4.29.2.10, J = 16. For a weapon firing in the direction prescribed by the orientation angles, the sign of the recoil force should normally be negative (i.e., opposite to the direction of firing).

4.25 SCAS GROUP (Include only if NPART = 2 or 4 and IPL(23) $\neq$ 0)

The Stability and Control Augmentation System (SCAS) is programmed to simulate an actual hardware system which provides improved stability and response to pilot inputs. The system block diagram is shown in Figure 34.

The quantities in Figure 34 are

B = control input (equal to appropriate stick input; see Figure 33)

B_G = SCAS feedforward added to stick input to offset feedback

B_H = SCAS feedback dependent on ship response

$S_M = B + B_G - B_H$ = total control input

G_P = feedforward transfer function

H = feedback transfer function

η = ship response variable (roll, pitch, or yaw); dots indicate time derivatives

The feedback transfer function has the following form:

$$H = \frac{B_H}{\dot{\eta}} = \frac{K_H (\tau_1 s + 1)(\tau_2 s + 1)}{(\tau_3 s + 1)(\tau_4 s + 1)(\tau_5 s + 1)}$$

where

s = Laplace Transform Operator $\frac{d}{dt}$ and the other variables are defined in terms of the inputs in Section 2.25.

The feedforward transfer function has the following form:

$$G_P = \frac{B_G}{\dot{B}} = \frac{K_G}{(\tau_3 s + 1)(\tau_4 s + 1)(\tau_5 s + 1)}$$

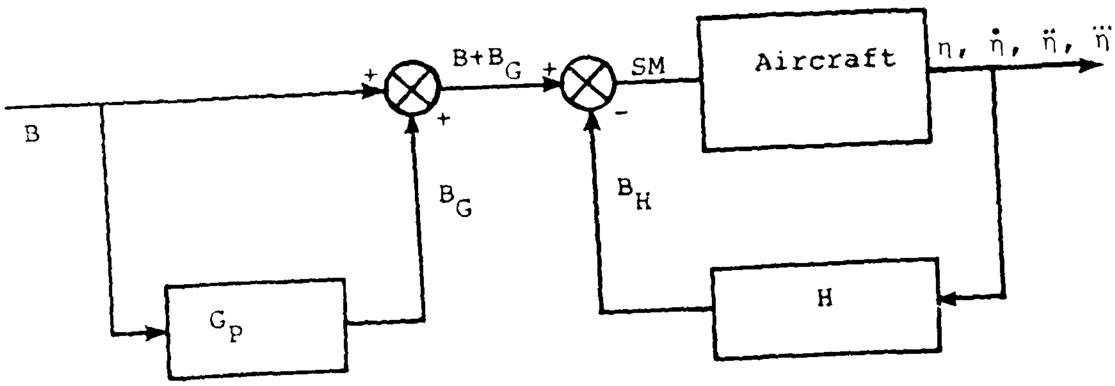


Figure 34. Block Diagram for SCAS Model.

In the program, these equations are written and solved in the form of differential equations:

$$C_1\dddot{B}_H + C_2\ddot{B}_H + C_3\dot{B}_H + B_H = C_4\dddot{\eta} + C_5\ddot{\eta} + K_H\dot{\eta}$$

$$C_1\dddot{B}_G + C_2\ddot{B}_G + C_3\dot{B}_G + B_G = K_G\dot{B}$$

where

$$C_1 = \tau_3\tau_4\tau_5$$

$$C_2 = \tau_3\tau_4 + \tau_4\tau_5 + \tau_3\tau_5$$

$$C_3 = \tau_3 + \tau_4 + \tau_5$$

$$C_4 = \tau_1\tau_2 K_H$$

$$C_5 = (\tau_1 + \tau_2)\, K_H$$

The variables used in the general equations above are defined in terms of the input variables for the three SCAS channels in the table below.

General Equation	Roll Channel	Pitch Channel	Yaw Channel
K_H	XSCAS(1)	XSCAS(8)	XSCAS(15)
K_G	XSCAS(7)	XSCAS(14)	XSCAS(21)
τ_1	XSCAS(2)	XSCAS(9)	XSCAS(16)
τ_2	XSCAS(3)	XSCAS(10)	XSCAS(17)
τ_3	XSCAS(4)	XSCAS(11)	XSCAS(18)
τ_4	XSCAS(5)	XSCAS(12)	XSCAS(19)
τ_5	XSCAS(6)	XSCAS(13)	XSCAS(20)
$\dot{\eta}$	roll rate	pitch rate	yaw rate

CARD 264

The SCAS has one independent channel for roll, pitch, and yaw. See Section 4.29.2.17, J=24, 25, and 26 for procedure to activate the system.

The maximum change that the roll channel of the SCAS may make is ± XSCAS(22) percent of the full range of the lateral cyclic. The maximum authorities in pitch and yaw are similarly defined.

The dead bands on the moment derivatives are used to negate the numerical noise that may be generated in the numerical differentiation process necessary to obtain these quantities. A value of 100 has been satisfactory for those cases run to date.

4.26 STABILITY ANALYSIS TIMES GROUP (Include only if NPART=2 or 4 and IPL(23) $\neq$ 0, or if NPART = 5)

The inputs to this group (the TSTAB array) specify the points during a maneuver where a rotorcraft stability analysis is to be performed. This rotorcraft stability analysis is the same as that performed after TRIM when NPART = 7 or when NPART = 10 and NVARC = 1.

The sign of each TSTAB input determines the units assigned to it. If the input is positive, its value is assumed to be time in seconds. If the input is negative, its absolute value is assumed to be the total azimuth angle of Blade 1 of Rotor 1 in degrees. This total azimuth angle is defined as zero degrees at maneuver time zero, and increases by 360 degrees for each complete rotor revolution. It is not necessary that the inputs be all positive (seconds) or all negative (degrees). However, it is mandatory that each TSTAB input specify a point in the maneuver that occurs after the point specified by the preceding TSTAB input. Hence, to avoid input errors, it is suggested that all inputs be in consistent units, particularly if the maneuver involves a change in rotor rpm.

It is emphasized that total azimuth angles are referenced to time zero. Hence, angles in the second rotor revolution are between 360 and 720 (inputs of -360.0 to -720.0); an input of -90.0 will only generate a rotorcraft stability analysis during the first rotor revolution.

NOTE: If the time-variant rotor analysis is activated (IPL(49) $\neq$ 0), rotorcraft stability analyses cannot be performed, and TSTAB(1) must consequently specify a time or azimuth angle which occurs after the end of the maneuver. Otherwise, execution will terminate at the time point corresponding to TSTAB(1). A value of 9999. (seconds) for TSTAB(1) is suggested in this case.

4.27 <u>BLADE ELEMENT DATA PRINTOUT GROUP</u> (Include only if NPART = 2 or 4 and IPL(23) $\neq$ 0 or if NPART = 5)

CARDS 281 and 282

The inputs to this group (the TAIR array) specify the points during the maneuver where blade element data are to be printed. TAIR inputs are interpreted in the same manner as TSTAB inputs (i.e., positive inputs are taken as seconds from the start of the maneuver and negative inputs as degrees of total azimuth angle for Blade 1 of Rotor 1). See Section 4.26 for a more complete discussion. The output obtained at the specified points may be dynamic loads only, aerodynamic loads only, or both, as discussed below.

If IPL(75) = 0 or 1, the beamwise bending moment, chordwise bending moment, and torsional moment are printed for each radial station on each blade of Rotor 1. These moments have been resolved through the blade pitch angle so they really are beamwise and chordwise.

If IPL(75) = 2, detailed aerodynamic data are printed for each radial station on each blade of Rotor 1 in addition to the bending moments.

IPL(76) controls the printout of the bending moment and aerodynamic data for Rotor 2.

Note that bending moment data will be printed only when the specified rotor uses the time-variant analysis. If printout of moment data is specified for a rotor that uses the quasi-static analysis, the program ignores the inputs and does not print the data. However, blade element aerodynamic data will be printed at the specified times regardless of the type of rotor analysis which is active.

4.28 <u>MANEUVER TIME CARD</u> (Include only if NPART = 2, 4, or 5)

CARD 291

This card and subsequent cards are to be included in the data deck only when running a maneuver; i.e., NPART = 2, 4, or 5 on CARD 01.

For NPART = 2 or 4, the start time, TCI(1), is assumed to be zero, and any other input is ignored. For NPART = 5, the start time is the time at which the maneuver is to be restarted; it must be greater than zero and less than the last time point of the maneuver being restarted. See discussion of CARD 01 for further details.

TCI(2) is used to specify the first base value of the time increment (Δt) between the calculation of maneuver time points. The Δt computed from TCI(2) will be used during the interval of TCI(1) to TCI(3) seconds of maneuver time. If TCI(2) < 1.0, the input is taken to be Δt in seconds. If TCI(2) $\geq$ 1.0, the input is taken to be the increment in Rotor 1 azimuth location in degrees between time points; in this case, the time increment to be used is defined as

$$\Delta t = TCI(2)/(6\Omega_1)$$

where Ω_1 is the rotational speed of Rotor 1 in units of rpm and Δt is in seconds.

To insure stability of the numerical integration technique during a time-variant maneuver (IPL(49) $\neq$ 0), the azimuth increment should always be less than or equal to 15 degrees. If aeroelastic blades are included in the simulation, an additional constraint is that at least 10 time points should be computed for each cycle of the highest natural frequency in the rotor mode shape data. For example, if the highest natural frequency is 3.0/rev, one cycle occurs every 120 degrees and the azimuth increment should then be less than or equal to 12 degrees. These requirements for the azimuth increment apply to time-variant trims as well as to time-variant maneuvers. If either unsteady aerodynamic option is activated (IPL(48) $\neq$ 0), the azimuth increment for maneuver should not be greater than about 15 degrees; 10 degrees or less is preferable.

It may be desirable to change the value of Δt because of a change in rotor speed. For this case, TCI(4) can be used to specify the value of Δt to be used between TCI(3) and TCI(5) seconds of maneuver time. Like TCI(2), TCI(4) may be either a time or azimuth increment. It is not necessary that TCI(2) and TCI(4) be the same type of increment; e.g., one may be

time and the other azimuth. Do not change the time increment in the period in which the rotor aeroelastic stability is being analyzed.

If TCI(6), the time to stop the maneuver, is greater than TCI(5), the program then uses the Δt based on TCI(2) between TCI(5) and TCI(6) seconds of maneuver time. If TCI(5) is the time to stop the maneuver, as well as the time to stop using the Δt based on TCI(4), the TCI(6) input may be zero or blank. If a second time increment is not desired, then TCI(4) and TCI(5) should be input as 0.0. In this case, TCI(6) will be ignored and TCI(3) is taken as the time to stop the maneuver.

When the time increment is changed during a maneuver, it may be desirable to change the frequency of printout of the time points; i.e., to change the value of NPRINT input on CARD 01. This may be done with a J = 31 card (see Section 4.29.2.22).

4.29 MANEUVER SPECIFICATION CARDS (May be included only if NPART = 2, 4, or 5)

CARD 301

THISJC Blank unless this is the last card of the 301 type.

J Type of variation, explained in list below.

If NPART = 2, 4, or 5, one card of the 301 type must be included and up to 20 may be included. All have the same format (A1, I4, 5X, 6F10.0). It is not necessary to have the J values in numerical order, and there may be several cards with the same value of J. It is necessary that THISJC be blank on all of these cards except the last one, which must have some alphanumeric character in the first column.

4.29.1 Summary of Permissible J Values

Permissible values of J are from 1 to 37. The type of variation that occurs for each value of J is given in the following list.

J = 1	movement of collective stick
J = 2	movement of longitudinal cyclic stick
J = 3	movement of lateral cyclic stick
J = 4	movement of pedal
J = 5	inactive
J = 6	folding rotors aft after tilting forward and stopping
J = 7 J = 8	inactive
J = 9	a vertical ramp gust; ramp length may be zero
J = 10	a vertical sine-squared gust
J = 11	a horizontal ramp gust; ramp length may be zero
J = 12	a horizontal sine-squared gust
J = 13	a change in engine torque supplied
J = 14	a change in auxiliary thrust supplied
J = 15	inactive
J = 16	weapon fire
J = 17	change of longitudinal mast tilt angle and of rpm on both rotors
J = 18	rotor brake
J = 19	inactive
J = 20	sinusoidal movement of controls or mast
J = 21 J = 22	inactive
J = 23	rpm-dependent hub springs
J = 24	SCAS roll channel

J = 25 SCAS pitch channel
J = 26 SCAS yaw channel
J = 27 folding rotors horizontally after stop
J = 28 rpm-dependent flapping stops
J = 29 connecting and disconnecting helicopter controls
J = 30 rotor moment balancing mechanism
J = 31 changing NPRINT
J = 32 simplified automatic pilot simulation
J = 33 inactive
J = 34 deployment of an aerodynamic brake
J = 35 dropping an external store
J = 36 changing incidence or control surface deflection angles of aerodynamic surfaces
J = 37 a trailing vortex system
J = 38
J = 39 inactive
J = 40
J = 41 p-tracker
J = 42 q-tracker
J = 43 r-tracker
J = 44 g-tracker
J = 45 Rate-of-climb tracker

4.29.2 Inputs for J-Cards

The input format for each of the currently available J-cards is given below. Start and stop times refer to the time from the start of maneuver unless otherwise noted.

4.29.2.1 J = 1, 2, 3, 4 (Control Movements)

Col 11-20	Start time for input rate 1	(sec)
21-30	Input rate 1	(in./sec)
31-40	Stop time for input rate 1	(sec)
41-50	Start time for input rate 2	(sec)
51-60	Input rate 2	(in./sec)
61-70	Stop time for input rate 2	(sec)

For normal control rigging, positive control rates correspond to up collective, forward longitudinal cyclic, right lateral cyclic and up Rotor 2 collective.

If the computed control position is greater than 100 percent or less than 0 percent, it is reset to 100 or 0 percent respectively. Hence, if a control is put on a stop by rate and time inputs that would normally put the control past its stop, subsequent rate and time inputs should be with respect to the stop, not to the imaginary position beyond the stop.

4.29.2.2 J = 5

J = 5 is currently inactive

4.29.2.3 J = 6 (Folding Rotors Aft)

Col	11-20	Start time (after Ω=0)	(sec)
	21-30	Rate (positive to fold aft)	(deg/sec)
	31-40	Stop time (after Ω=0)	(sec)
	41-50	Start time (after Ω=0)	(sec)
	51-60	Rate (positive to fold aft)	(deg/sec)
	61-70	Stop time (after Ω=0)	(sec)

4.29.2.4 J = 7, J = 8

J = 7 and 8 are currently inactive

4.29.2.5 J = 9 and 11 (Vertical and Horizontal Ramp Gust, Respectively) (see Figure 35)

Col	11-20	(1) Starting distance (in ground X-Y plane)	(ft)
	21-30	(2) 1st max velocity (positive down or north)	(ft/sec)
	31-40	(3) 1st ramp length	(ft)
	41-50	(4) Distance gust is steady	(ft)
	51-60	(5) 2nd ramp length	(ft)
	61-70	(6) 2nd max velocity (measured from first max velocity)	(ft/sec)

NOTE: J = 9 or 11 may only be used once per maneuver run.

4.29.2.6 J = 10 and J = 12 (Vertical and Horizontal Sine-Squared Gust, Respectively) (see Figure 36)

Col	11-20	(1) Starting distance	(ft)
	21-30	(2) 1st max value (positive down or north)	(ft/sec)
	31-40	(3) 1st gust length	(ft)
	41-50	(4) Distance between gusts	(ft)
	51-60	(5) 2nd gust length	(ft)
	61-70	(6) 2nd max value	(ft/sec)

NOTE: J = 10 or 12 may only be used once per maneuver run.

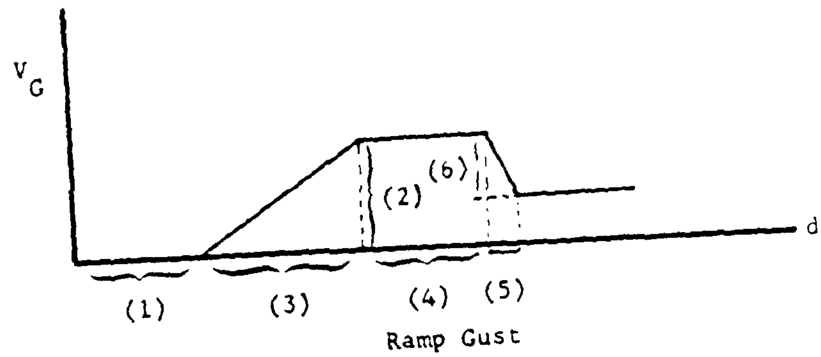


Figure 35. Definition of Terms Describing Gust Velocity Versus Distance for a Ramp Gust.

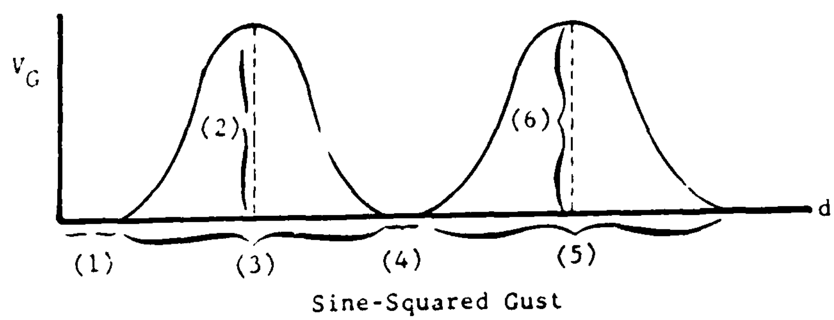


Figure 36. Definition of Terms Describing Gust Velocity Versus Distance for Sine-Squared Gusts.

4.29.2.7 <u>J = 13 (Main Engine Torque)</u>

Col 11-20	Start time for rotor torque supplied variation	(sec)
21-30	Ratio of torque desired to torque required at trim point	(ft-lb/ft-lb)
31-40	Start time for rotor torque supplied recovery to torque required	(sec)
41-50	(Inactive)	
51-60	Engine acceleration lag, zero to full power	(sec)

4.29.2.8 <u>J = 14 (Auxiliary Jet Thrust)</u>

Col 11-20	Start time for jet thrust variation	(sec)
21-30	Type of variation indicator, TVI	
31-40	Rate of change of jet thrust, RJT	(lb/sec)
41-50	Stop time for variation	(sec)
51-60	Final value of jet thrust	(lb)
61-70	Affected jet; = 1.0 for left jet, = 2.0 for right jet	

Three types of jet thrust variation are possible based on the value of TVI.

If TVI = 0.0, the rate RJT acts for the specified time, i.e., the stop time minus start time. The input for the final value of jet thrust is ignored in this case.

If TVI = 1.0, the rate RJT acts until the final value of jet thrust specified in columns 51 to 60 is attained. The input for the stop time is ignored in this case.

Following one or more J = 14 cards where TVI = 0.0 or 1.0, it may be desirable to change the jet thrust back to its value at the start of the maneuver, the trim value. To do this, set TVI = 2.0, which will cause the final value of thrust (columns 51 to 60) to be reset to the trim value and TVI to be reset to 1.0. The specified rate will then act until the jet thrust returns to the trim value. The input stop time is ignored in this case. TVI should not equal 2.0 unless a previous J = 14 card has changed the jet thrust from the trim value.

The jet selector (in columns 61-70) must be 1.0 or 2.0. Any other value will result in erroneous calculations.

4.29.2.9 <u>J = 15</u>

J = 15 is currently inactive

4.29.2.10 J = 16 (Machine Gun Fire, Ramp Only) (see Figure 37)

Col 11-20	(1) Start time		(sec)
21-30	(2) Stop time		(sec)
31-40	(3) Max force (normally negative)		(lb)
41-50	(4) Ramp length		(sec)
51-60	Inactive		
61-70			

For the normal case of a weapon firing forward, the reaction force should be negative. See the Weapons Group (Section 4.24) for additional details.

4.29.2.11 J = 17 (Longitudinal Mast Tilt on Both Rotors) (see Figure 38)

Col 11-20	Start time for mast tilt	(sec)
21-30	Rate of mast tilt	(deg/sec)
31-40	Stop time for mast tilt	(sec)
41-50	(Inactive)	
51-60	α, mast tilt angle at which rpm change is activated	(deg)
61-70	$\Omega_H - \Omega_A$, change in rpm in converting from airplane mode to helicopter mode	(rpm)

$$\Omega = \begin{cases} \Omega_A + (\Omega_H - \Omega_A)*\cos[90(\beta_m-\alpha)/(90-\alpha)] & \text{if } \beta_m > \alpha \\ \Omega_H & \text{if } \beta_m \le \alpha \end{cases}$$

where

βm = longitudinal mast tilt angle

Ω = current rotor rpm

Ω_H = rotor rpm in helicopter mode (β_m = 0°)

Ω_A = rotor rpm in airplane mode (β_m = 90°)

4.29.2.12 J = 18 (Rotor Brake)

Col 11-20	Maximum brake torque	(ft-lb)
21-30	RPM at which brake engages, Ω_b	(rpm)
31-40	Target azimuth position for stop	(deg)
41-50	Time to stop applying brake	(sec)
51-60	Inactive	
61-70		

4.29.2.13 J = 19

J = 19 is currently inactive

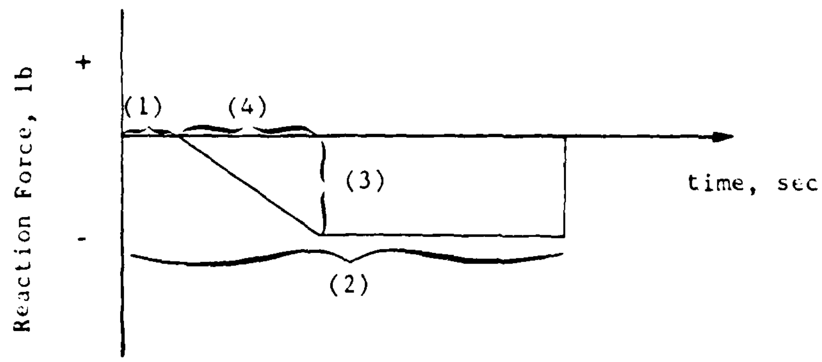
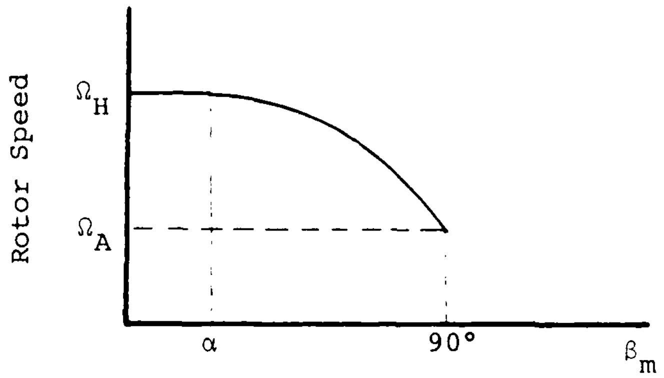


Figure 37. Definition of Terms Describing the Weapon Recoil Force Versus Time.



$$\Omega = \begin{cases} \Omega_A + (\Omega_H - \Omega_A) * \cos\left[90(\beta_m - \alpha)/(90-\alpha)\right] & \text{if } \beta_m > \alpha \\ \Omega_H & \text{if } \beta_m \leq \alpha \end{cases}$$

Figure 38. Definition of Terms Describing the Variation of Rotor Speed with Mast Angle.

4.29.2.14 <u>J = 20 (Sinusoidal Movement of Controls or Mast)</u>

Col	11-20	Start time	(sec)
	21-30	Frequency	(Hz)
	31-40	Amplitude	(in./deg)
	41-50	Stop time	(sec)
	51-60	Control to be moved	
	61-70	Inactive	

Amplitude is in inches for controls or in degrees for mast tilt. The code for the control to be moved is

1.0 = Collective stick
2.0 = Longitudinal cyclic stick
3.0 = Lateral cyclic stick
4.0 = Pedal
5.0 = Longitudinal mast tilt

Note that if the control code is 5.0, the longitudinal mast tilt angle of <u>both</u> rotors is varied.

4.29.2.15 <u>J = 21 and 22</u>

J = 21 and 22 are currently inactive

4.29.2.16 <u>J = 23 (RPM-Dependent Hub Springs)</u>

Col	11-20	Rotor number (1.0 or 2.0)	(ft-lb/deg)
	21-30	K_B hub spring value in lower rpm range	(rpm)
	31-40	Ω_1 top of lower rpm range	(rpm)
	41-50	Ω_2 bottom of upper rpm range	(rpm)
	51-60 61-70	Inactive	

Let Ω be the rpm of Rotor 1, K_I be XMR(18) or XTR(18), as appropriate, and K_h be the rpm-dependent value of the appropriate hub spring. Then

$$K_h = \begin{cases} K_I & \text{if } \Omega \geq \Omega_2 \\ \dfrac{K_B - K_I}{\Omega_I - \Omega_2} (\Omega - \Omega_2) + K_I & \text{if } \Omega_1 < \Omega < \Omega_2 \\ K_B & \text{if } \Omega \leq \Omega_1 \end{cases}$$

In other words, the extreme values for the hub springs are K_B, and the input in the appropriate rotor group is K_I. Linear interpolation is used in the transition region.

4.29.2.17 J = 24, 25, 26 (SCAS Channels)

Col 11-20	Time to activate SCAS channel	
21-30	Time to turn off SCAS channel	
31-40	Inactive	
41-50	Inactive	
51-60	Inactive	
61-70	Inactive	

4.29.2.18 J = 27 (Horizontal Fold, for Rotor 1 Only)

Col 11-20	Start time	(sec after Ω=0)
21-30	Rate	(deg/sec)
31-40	Stop time	(sec after Ω=0)
41-50	Blade number (each blade moves independently)	
51-60	Inactive	
61-70	Inactive	

4.29.2.19 J = 28 (RPM-Dependent Flapping Stops)

Same as for J = 23 except that mechanism affected is flapping stops and K_B is in degrees.

4.29.2.20 J = 29 (Control Changer - to Lock or Unlock Swashplate)

Col 11-20	Start time	(sec)
21-30	Stop time	(sec)
31-40	Indicator; = 0.0 if start time is in maneuver seconds, $\neq$ 0.0 if start is in seconds after Ω=0.0	
41-50	Indicator; = 0.0 if stop time is in maneuver seconds, $\neq$0.0 if stop time is in seconds after Ω=0.0	
51-60	Indicates which controls to lock or unlock; 1.0 is for Rotor 1 collective; 2.0 is for Rotor 1 longitudinal cyclic; 4.0 is for Rotor 1 lateral cyclic; 8.0 is for Rotor 2 collective. For any combination, add the indicators. 0.0 is equivalent to 15.0, which affects all controls.	
61-70	Inactive	

If this mechanism is switched off during a maneuver, swashplate settings will immediately assume the value dictated by the control positions. Care should be taken to set the controls so that there are no discontinuities.

4.29.2.21 J = 30 (Mechanism for Balancing Rotor 1 Force and Moments During Horizontal Fold)

Col 11-20	Start time	(sec after Ω=0)
21-30	Stop time	(sec after Ω=0)
31-40	∂(Z-force)/∂(collective)	(lb/deg)
41-50	∂(longitudinal flapping moment)/ ∂(longitudinal cyclic)	(ft-lb/deg)
51-60	∂(lateral flapping moment)/ ∂(lateral cyclic)	(ft-lb/deg)
61-70	Maximum rate of change of controls (collective and cyclic)	(deg/sec)

4.29.2.22 J = 31 (Changing Printout Frequency)

Col 11-20	Time to change NPRINT	(sec)
21-30	New NPRINT	
31-40	Time to change NPRINT	(sec)
41-50	New NPRINT	
51-60	Time to change NPRINT	(sec)
61-70	New NPRINT	

NPRINT must be input as a floating number; therefore, punch a decimal point on the data card. The use of NPRINT is as described for CARD 01, NPART = 2.

As an example of the use of this value of J, as well as an example of the use of the provision for different time increments on CARD 291, consider the following hypothetical situation.

A maneuver was run in which a pitch divergence occurred. Analysis of the output indicated that the divergence started between 3.5 and 3.75 seconds. The time increment used was .05 and NPRINT was 5 throughout the run, which lasted 7.5 seconds.

A new maneuver was then set up, identical to the first except that the time card, CARD 301, now contained 0.0, 0.05, 3.5, 0.005, 3.75, 3.75 as the consecutive inputs instead of 0.0, 0.05, 7.5, blank, blank, blank which were used on the previous run. NPRINT on CARD 01 was changed from 5 to 70. An additional CARD 301 was input which had a J of 31. The number 3.5 was in Columns 11-20, the number 1.0 in Columns 21-30, and the rest of the card was blank.

In the output (see Section 6 for a complete explanation of all outputs), the trim page was followed by the maneuver page for maneuver time of 0.0 second. The next time point for which output was given was 3.5 seconds and output was given at every 0.005 second until 3.75 seconds. The result was no output for time points of no interest, but complete coverage of the time interval of interest.

4.29.2.23 J = 32 (Automatic Pilot)

Col	Description	Units
11-20	Time to activate autopilot	(sec)
21-30	Maximum rate for cyclic stick motion	(%/sec)
31-40	Maximum rate for collective stick motion	(%/sec)
41-50	Maximum rate for pedal motion	(%/sec)
51-60	Time interval to zero rates	(sec)
61-70	Time interval to zero displacements	(sec)

CAUTION: At least one partial derivative matrix must be computed prior to activating the Automatic Pilot. Without such a matrix, execution will terminate when the Automatic Pilot is activated. Also, when used, this must be the last J-card.

The Automatic Pilot control corrections are determined from the simultaneous solution of the three moment equations and the Z-force equation with the moment and force imbalances as the coefficient terms. The dependent variables are the control corrections. If there is a prescribed input from any of the controls (J=1, 2, 3, or 4), the Automatic Pilot will not move that control.

4.29.2.24 J = 33 is currently inactive.

4.29.2.25 J = 34 (Aerodynamic Brake Deployment)

Col	Description	Units
11-20	Time to start change in deployment	(sec)
21-30	Rate of deployment change	(%/sec)
31-40	Time to stop change in deployment	(sec)
41-50	Brake number	
51-60	Inactive	
61-70	Inactive	

The Brake Number (Col 41-50) must be 1, 2, 3, or 4, which corresponds to the first, second, third, or fourth subgroup of the External Stores/Aerodynamic Brake Group (CARDS 201A-204C). If the Brake Number specified corresponds to a subgroup that is supposed to be an external store, i.e., has a weight greater than zero, execution is terminated. Deployment is stopped at 0 or 100 percent regardless of the rate and time inputs.

4.29.2.26 J = 35 (External Store Drop)

Col	11-20	Time to drop store (t_D)	(sec)
	21-30	Sequence number of store to be dropped	
	31-40	Duration of jettison reaction forces (Δt_{JF})	(sec)
	41-50	X-Reaction force (+ forward)	(lb)
	51-60	Y-Reaction force (+ right)	(lb)
	61-70	Z-Reaction force (+ down)	(lb)

The sequence number of the store to be dropped must be 1.0, 2.0, 3.0, or 4.0, i.e., the first, second, third, or fourth Store/Brake subgroup. If the sequence number corresponds to a subgroup that is not used or is an aerodynamic brake rather than a store (weight $\leq$ 0 instead of > 0), execution will terminate. The jettison reaction forces start acting at the drop time (t_D) and stop at $t_D + \Delta t_{JF}$ seconds of maneuver time. The reaction forces are defined in body axis. For example, if a store is jettisoned straight down, the reaction force will be up and the Z-direction reaction force (Col 61-70) should be negative.

4.29.2.27 J = 36 (Change of Incidence or Control Surface Angles)

Col	11-20	Start time	(sec)
	21-30	Rate of angle change	(deg/sec)
	31-40	Stop time	(sec)
	41-50	Surface indicator, SI	
	51-60	Type of change indicator, CI	
	61-70	(Inactive)	

The surface indicator, SI, specifies which surface is involved.

$$SI = \begin{cases} 0 \text{ or } 5 \text{ for wing} \\ 1, 2, 3, \text{ or } 4 \text{ for Stabilizing Surface No. 1, No. 2,} \\ \quad \text{No. 3, or No. 4 respectively} \end{cases}$$

The type of change indicator, CI, specifies the angle to be changed.

$$CI \begin{cases} = 0.0 \text{ for change of incidence angle} \\ \neq 0.0 \text{ for change of control surface, or flap, angle} \end{cases}$$

For the wing, the angle change is symmetrical. For all surfaces, positive incidence change is leading edge up; positive control surface deflection is trailing edge down.

4.29.2.28 J = 37 (Trailing Vortex System)

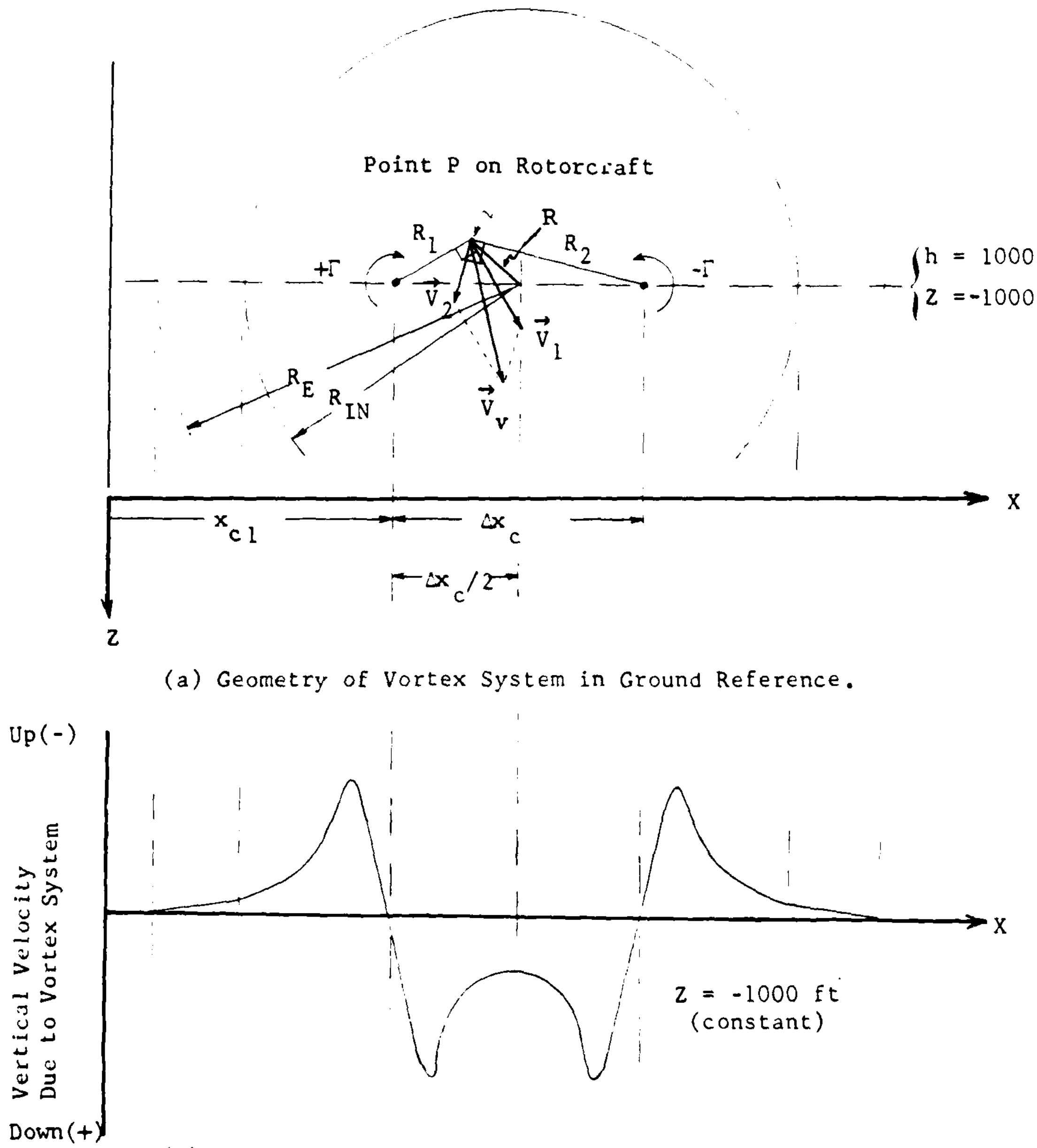
Col 11-20	X-distance to center of first core (x_{c1})	(ft)
21-30	X-distance between core centers (Δx_c)	(ft)
31-40	Circulation strength of first vortex (Γ)	(ft^2/sec)
41-50	Core size factor (K_c)	(ft^2)
51-60	Distance in the X-Z plane from center of vortex system to start of vortex velocity field (R_E)	(ft)
61-70	Distance in the X-Z plane from center of vortex system to where the rotorcraft is completely within the vortex velocity field (R_{IN})	(ft)

The trailing vortex system consists of two equal-strengthed, counterrotating vortices. The system is defined in the X-Z plane of the ground reference system as shown in Figure 39. Note that the vortex pair is located at a geometric altitude of 1000 feet, so that the vertical distance between the vortex pair system and the helicopter is 1000 - XFC(4) .

The velocity at a point P on the rotorcraft due to the vortex system is

$$\vec{V}_v = \begin{cases} 0 \text{ if } R \geq R_E \\ (\vec{V}_1 + \vec{V}_2) \cos^2 (RF) \text{ if } R_E > R > R_{IN} \\ \vec{V}_1 + \vec{V}_2 \quad \text{if } R \leq R_{IN} \end{cases}$$

where R is the distance from the center of the vortex system to the point; $\vec{V}_1$ and $\vec{V}_2$ are the vortex velocity vectors at the point due to the first and second vortex, respectively; RF is a phasing factor; and R_E and R_{IN} are inputs.



(a) Geometry of Vortex System in Ground Reference.

(b) Vertical Velocity due to Vortex System at Constant Altitude in Ground Reference.

Figure 39. Trailing Vortex System Model.

$$\vec{V}_1 = \frac{\Gamma}{2\pi R_1} \left(1-e^{-R_1^2/K_c}\right)$$

$$\vec{V}_2 = \frac{\Gamma}{2\pi R_2} \left(1-e^{-R_2^2/K_c}\right)$$

$$RF = \frac{\pi}{2} \quad \frac{R-R_{IN}}{R_E-R_{IN}}$$

where R_1 and R_2 are the distances from the centers of the first and second vortex, respectively, to the point on the rotorcraft and K_c is an input.

Note that the velocity field is independent of ground reference Y-location (i.e., the velocity along any line parallel to the ground Y-axis is constant). Hence, by inputting appropriate values of forward and lateral velocities, rate of climb, and heading angle (XFC(1), (2), (3), and (5) respectively), the vortex velocity field can be approached from any desired angle. The body axis components of the velocity at the rotorcraft cg due to the vortex system are printed under the headings of gust velocities on the maneuver-time-point page of the printout. Velocities at other points on the rotorcraft are not printed out.

CAUTION: As with horizontal and vertical gusts (J = 9, 10, 11, or 12), be sure that the inputs do not put the rotor into the velocity field too early. As a rule of thumb, $(x_{c1} + \Delta x_c/2 - R_E)$ should be greater than the rotor radius.

4.29.2.29 J = 38, 39, and 40

J = 38, 39, and 40 are currently inactive.

4.29.2.30 J = 41 (Roll Rate Input to Autopilot (P-Tracker))

Col 11-20	Time to start variation of desired roll rate	(sec)
21-30	First rate of change of desired roll rate	(deg/sec/sec)
31-40	Time to stop first rate	(sec)
41-50	Time to start second variation	(sec)
51-60	Second rate of change of desired roll rate	(deg/sec/sec)
61-70	Time to stop second rate	(sec)

This input is used to track an input roll-rate time history. Do not input a J = 3 card (normal control rigging). The user <u>must</u> input a J = 32 card.

4.29.2.31 J = 42 (Pitch Rate Input to Autopilot (Q-Tracker))

Col	11-20	Time to start variation of desired pitch rate	(sec)
	21-30	First rate of change of desired pitch rate	(deg/sec/sec)
	31-40	Time to stop first rate	(sec)
	41-50	Time to start second variation	(sec)
	51-60	Second rate of change of desired pitch rate	(deg/sec/sec)
	61-70	Time to stop second rate	(sec)

This input is used to track an input pitch-rate time history. Do not input a J = 2 card (normal control rigging). The user must input a J = 32 card.

4.29.2.32 J = 43 (Yaw Rate Input to Autopilot (R-Tracker))

Col	11-20	Time to start variation of desired yaw rate	(sec)
	21-30	First rate of change of desired yaw rate	(deg/sec/sec)
	31-40	Time to stop first rate	(sec)
	41-50	Time to start second variation	(sec)
	51-60	Second rate of change of desired yaw rate	(deg/sec/sec)
	61-70	Time to stop second rate	(sec)

This input is used to track an input yaw-rate time history. With normal control rigging for a single-main-rotor helicopter, the user should not input a J = 4 card. A J = 32 card must be input.

4.29.2.33 J = 44 (Normal Load Factor Input to Autopilot (G-Tracker))

Col	11-20	Time to start variation of desired normal load factor	(sec)
	21-30	First rate of change of desired normal load factor	(g/sec)
	31-40	Time to stop first rate	(sec)
	41-50	Time to start second variation	(sec)
	51-60	Second rate of change of desired normal load factor	(g/sec)
	61-70	Time to stop second rate	(sec)

The normal load factor input is used to simulate a cyclic-only, symmetric pullup or pushover with a specified normal load factor time history. A J = 32 card must be input and, with normal control rigging, the user should not input a J = 2 card. A J = 1 card must be input.

4.29.2.34 J = 45 (Rate-of-Climb Input to Autopilot (RC-Tracker))

Col 11-20	Time to start variation of desired rate of climb	(sec)
21-30	First rate of change of desired rate of climb	(ft/sec/sec)
31-40	Time to stop first rate	(sec)
41-50	Time to start second variation	(sec)
51-60	Second rate of change of desired rate of climb	(ft/sec/sec)
61-70	Time to stop second rate	(sec)

This input is used to track an input rate-of-climb time history. A J = 32 card must be input.

4.30 CONFIGURATION DETERMINATION

The program examines several inputs to determine the configuration of the rotorcraft which is being simulated. The inputs are

XTR(45),	Rotor 2 lateral mast tilt
XFS(5),	the stationline of the rotorcraft cg
XMR(8),	the stationline of Rotor 1 shaft pivot point
XTR(8),	the stationline of Rotor 2 shaft pivot point

Using the following definitions

$$(l_x)_{R1} = (XMR(8) - XFS(5))/12$$

$$(l_x)_{R2} = (XTR(8) - XFS(5))/12$$

and the following logic

TRIND = 0

TRIND1 = 0

IF $|XTR(45)| < 45°$, TRIND = 1

IF TRIND $\neq$ 0 and $|(l_x)_{R1}-(l_x)_{R2}| \leq 5$ feet, TRIND1 = 1

the value of the configuration variable KONFIG is then defined as

$$KONFIG = 1. + TRIND + TRIND1$$

Based on the value of KONFIG, the program assigns names to the input rotor groups and assumes a type of configuration as shown in Table 21.

TABLE 21. ROTOR NAMING CONVENTION

Value of KONFIG	Defined Configuration	Names Assigned by Program Rotor 1	Rotor 2
1	Single-main-rotor helicopter	MAIN	TAIL
2	Tandem-rotor helicopter	FORWARD	AFT
3	Side-by-Side*	RIGHT	LEFT

* Same as tilt-rotor, composite, or coaxial.

The value of KONFIG is then used as follows:

(1) To determine if the Supplemental Rotor Controls Subgroup should be input, i.e., if KONFIG $\neq$ 1, an error message is generated, since the other two configurations cannot be controlled without the XCRT array.

(2) To eliminate numeric "noise" in the partial derivatives for a particular configuration, e.g., if the Supplemental Rotor Controls Subgroup is not input for KONFIG = 1, the Rotor 1 flapping moments due to pedal displacement and the Rotor 2 flapping moments due to displacement of collective and cyclic sticks are set to zero.

(3) To define the names to be printed in the output heading for each rotor.

(4) To modify control linkages or angles to be compatible with the configuration.

Note that in naming the rotors, the value of KONFIG may not assign the name expected to a particular rotor. For example, consider a tandem-rotor helicopter. In naming the rotors, the program assumes that the front rotor rotates counterclockwise and was input to the Rotor 1 Group and that the aft rotor rotates clockwise and was input to the Tail Rotor Group. However, the user may want to reverse the rotation of each rotor, in which case the aft rotor would be input to the Main Rotor Group and the forward rotor to the Tail Rotor Group.

The program does not check to see if the rotor it is calling FORWARD is actually forward of the other rotor. Hence, if the user does swap rotor groups to reverse their rotation, the program will be ignorant of it and will still call the rotor input to the Rotor 1 Group the FORWARD rotor. This rotor will be in front of the REAR rotor for positive values of the airspeed, XFC(1). The same situation applies to the RIGHT and LEFT rotors of side-by-side configurations, so that the RIGHT rotor will be to the right of the LEFT rotor for positive values of the airspeed, XFC(1). A coaxial configuration is treated like a side-by-side; its rotors are named RIGHT and LEFT rather than indicating which rotor is on the top or bottom.

Note, however, when swapping rotor groups that the sign conventions for positive lateral swashplate angle are not the same for both rotors. Hence, the user should check all control linkages prior to running a deck with swapped rotors.

5. USER'S GUIDE TO THE INPUT FORMAT FOR GDAP80

Data generated by AGAP80 can be postprocessed using Program GDAP80, which is automatically invoked following an AGAP80 run. All inputs to GDAP80 must follow all inputs to AGAP80. Data to be postprocessed must have been generated by the AGAP80 run, e.g., requesting plots of Rotor 2 bending moments will be meaningless (because the plots will show a constant value) unless that rotor was subjected to a time-variant analysis and was represented by elastic mode shapes in the case that generated the Postprocessing Data Block.

The data to be postprocessed by GDAP80 have been stored in one or more Postprocessing Data Blocks (PDB) as they were created by AGAP80. The data in these PDBs came from one of three sources:

(1) a quasi-static trim for which IPL(79)≠0 (the PDB contains data for blade 1 of both rotors)

(2) a time-variant trim of either rotor (the PDB contains data only for the rotor being analyzed)

(3) a maneuver (the PDB contains all maneuver time-history data)

Since the data in any one PDB are generally completely independent of the data in any other PDB, the postprocessing instructions for a particular PDB are input to GDAP80 in a unique set. Each such set can contain instructions to perform any of the following operations, with certain restrictions:

(1) Plot time histories of selected data (NPART=3)

(2) Perform a stability analysis of time-history data using the Moving Block Fast Fourier Transform procedure (NPART=6)

(3) Store maneuver time-history data on magnetic tape for future postprocessing (NPART=8)

(4) Perform a harmonic analysis of time-history data (NPART=9)

(5) Perform a vector analysis of time-history data (NPART=11)

(6) Tabulate or contour plot rotor aerodynamic data (NPART=12)

(7) Perform a stability analysis of time-history data using Prony's method (NPART=13)

(8) Create a Data Transfer File (NPART=15)

Those operations in which time-history data are processed (NPART=3,6,9,11,13 and 15) should only be requested for PDBs which contain such data, i.e., PDBs resulting from time-variant trims and maneuvers. NPART=8 copies all PDBs to magnetic tape regardless of which PDB is being processed when it is invoked. After the data are copied to tape, GDAP80 rewinds to the beginning of the first PDB in the file. It is recommended that the NPART=8 option be invoked, if needed, as the last GDAP80 option for the last PDB. With the exception of this tape-writing operation, all the GDAP80 postprocessing operations may be invoked as many times as necessary in the instruction set for a particular PDB.

The variables to be postprocessed are specified by unique code numbers. The code numbers used for the tabulations and contour plots of rotor variables (NPART=12) select entire families of data, and are to be found in Table 12 in Section 5.7. The code numbers for all other postprocessing operations can be found in Table 27 in Section 9. Unless otherwise noted, the end of a list of variables is denoted by placing an alphanumeric character (a slash is recommended) in card Column 1 of the last card in the list.

Program GDAP80 automatically rewinds the file of Postprocessing Data Blocks generated by the preceding AGAP80 step and prepares to process the data in the first PDB, using the set of instructions input immediately after the AGAP80 inputs.

5.1 INDEXING POSTPROCESSING DATA BLOCKS

The NPART=14 card is used to terminate the list of postprocessing instructions pertaining to a particular PDB. Upon reading an NPART=14 card, GDAP80 indexes the AGAP80-generated file of data to the beginning of the next PDB and prepares to execute the next set of postprocessing instructions.

The user may avoid processing data in a particular PDB by using an NPART=14 card in the following manner:

(1) Should the user wish to skip the first PDB, the first card input to GDAP80 should be an NPART=14

card. This signifies the end of postprocessing on the first PDB (which was automatically queued up at the initiation of GDAP80) and causes the program to index to the beginning of the second PDB. The postprocessing instructions for the second PDB follow this NPART=14 card.

(2) A PDB other than the first may be skipped by using two NPART=14 cards at the end of the postprocessing instructions for the PDB preceding the PDB to be skipped. The first NPART=14 card signifies the end of the postprocessing instructions for the PDB being processed and causes GDAP80 to index to the beginning of the PDB to be skipped. Since the user does not wish to perform any postprocessing operations on the data in this PDB, no postprocessing instructions are input. The second NPART=14 card signifies the end of the (null) set of postprocessing instructions and GDAP80 indexes to the beginning of the next PDB.

The set of postprocessing instructions for the last PDB in the file need not be terminated with an NPART=14 card.

See Figure 40 for examples of the use of the NPART=14 card.

```
   ..                                           ..3     -3.33333   2..
                                                4.5      8.1250    5.3
                                     0.6        6.6      6.3333    7.0
                        ..17647      9.0        9.0      0.0       10.0
/  32       0.0         100.0        100.0      100.0    0.1       0.1
14
3   3
2626   160    320     1
2627   161    320     1
2628   162    320     1
2629   2637   320     1
/2630  175    320     1
 6                       0.185     5.4          2.7                10
/         353      2                       1           1
                   3     5.4
11
  301     302    303
     2    301    302    303
  303     301    302
13    1
/     1   353    21    1  0.185   1.1111
```

End of Maneuver Specification Cards

NPART = 14 card used to cause GDAP80 to skip the first PDB, which was automatically created during TVT

GDAP80 inputs to control postprocessing of data in PDB generated during maneuver simulation

Figure 40. Example of Use of NPART = 14 Card

5.2 PLOTTING OF TIME-HISTORY DATA

Whenever time-history data are available, the 20-series cards may be used to plot the data. This procedure is an option. If it is not to be used, simply omit the 20-series cards. The data may be plotted on the computer printer or put on tape for plotting by the CALCOMP plotter. Consult your local programmer for the proper setup for jobs that write a tape for CALCOMP plotting.

Time-history data are stored after all time-variant trim cases and for maneuvers and may be plotted by inserting 20-type cards in the data deck. If only one time-variant trim is being performed, a 21-type card and up to 10 22-type cards are placed immediately after the Flight Constants Group.

CARD 21

Column 2 must contain the integer 3 to call the plotting routine. NPRINT specifies that the first and every NPRINTth data point following are to be plotted. If NPRINT = 0, it is reset to unity.

CARDS 22A, 22B, etc.

The first card column of all but the last 22-type card must be blank. The first card column of the last 22-type card must contain a character (a slash is recommended).

One 22-type card is required for each plot. A maximum of 10 of these cards is permitted after each CARD 21. Each plot may contain one to three variables. The first three inputs on a 22-type card are the code numbers for the variable(s) to be plotted. The code numbers must be integers and must be right justified in the appropriate field. If only one variable is to be plotted, the code numbers must be in Columns 3-5; if only two are to be plotted, only columns 3-5 and 8-10 are to be used. The code numbers are given in Section 9.

KEY (column 20) controls where the plotting is done.

= 0 for CALCOMP only
= 1 for printer only
= 2 for both

The program internally computes its own scales for plotting each variable based on the maximum and minimum values of the variables during the time history and internally specified minimum scales. The internal minimum scale may be overridden for each variable with the last three inputs on the 22-type card. The minimum scale inputs are in units of the appropriate

variable per inch for printer plots and units per centimeter for CALCOMP plots.

If the user wishes to plot more variables than permitted on the 22-type cards, then another 21-type card should be inserted in the instruction set, followed by up to 10 more 22-type cards.

5.3 STABILITY ANALYSIS USING MOVING BLOCK FAST FOURIER TRANSFORM

The stability of any of the time-history variables listed in Section 9 can be examined by a moving block fast Fourier transform analysis. The use of the analysis is controlled by the 30-series cards, which must be omitted if this option is not to be invoked.

CARD 31

Column 2 must contain the integer 6 to call the moving block FFT analysis.

CARD 32A, 32B, etc. ...

All except the last of these cards must have card column 1 blank. The last CARD 32 must have some alphanumeric character in the first column to signify the end of the list.

The variable numbers are given in Section 9. The code number must be right-justified in the field.

The analysis uses the values of the selected variable in the time period between t_o and $t_o + \Delta t$, where

t_o = Input start time

$\Delta t = 1.5(N/f)$

N = Number of cycles, at frequency f, to be analyzed

f = Central frequency for analysis

Δf = Half bandwidth for analysis

Therefore, t_o must be chosen so that there are at least 1.5*N cycles, at the frequency f, before the end of the time-history.

The analysis then divides the data up into several overlapping blocks, each of which is N/f seconds long, and searches for the best-fit response frequency in the bandwidth $f-\Delta f$ to $f+\Delta f$. This best-fit frequency and the damping ratio for the variable are printed out. See Section 13 of Volume 1 of Reference 1 for more details of the analysis.

Experience with this option has indicated that the results are very sensitive to several parameters. For example, experiments with this analysis have shown significant variation in computed natural frequencies and damping ratios due to changes in block length, even for simple waveforms. It is recommended that the Prony stability analysis (Section 5.8) be used wherever possible.

5.4 STORING TIME-HISTORY DATA ON TAPE

CARD 41

Following a maneuver (NPART = 2, 4, or 5), it may be desirable to store the time history on tape so that the data can be recalled later for additional analysis or plotting. Inputs of 8 and 0 in Columns 2 and 15 respectively will store the data. However, consult your local programmer for the proper setup of the job before attempting to use this option. See NPART = 8 or AGAP80 CARD 01 for instructions on retrieving the data that a CARD 41 stores.

NOTE: This instruction should only be used for the PDB resulting from the maneuver portion of a run.

5.5 HARMONIC ANALYSIS OF TIME-HISTORY DATA

When time history data are available, the 50-series cards may be used to perform harmonic analysis of specified variables. This procedure is an option. If it is not to be used, simply omit the 50-series cards. Consult your local programmer for proper setup of jobs which write a tape for CALCOMP plotting. Refer to Section 9 for the code numbers discussed below.

CARD 51

NPART in Column 2 must contain the integer 9 to call the harmonic analysis routine.

AL(1) is the start time and AH(1) is the stop time for the analysis. Both times are measured in seconds from the start time of the time history. The difference between the two times is referred to as Δt_A, the time interval for analysis:

$$\Delta t_A = AH(1) - AL(1)$$

NVARA is the total number of variables that are to be analyzed. NVARA must be less than or equal to 14 and an integer input.

AL(2) specifies the baseline frequency (ω) for the analysis. If AL(2) > 0.0, the input is taken to be ω in hertz. If AL(2) = 0.0, ω is set equal to the main rotor 1-per-rev frequency.

$$\omega = \Omega_1/60$$

where Ω_1 is the rotation speed of Rotor 1 in rpm. If AL(2) $\leq$ 0.0.

$$\omega = \Omega_2/60$$

where Ω_2 is the Rotor 2 rpm. If AL(2) $\leq$ 0.0 and the rotor rpm changes during Δt_A, the appropriate 1-per-rev frequency at AL(1) seconds maneuver time will be used for the analysis.

If AL(2) $\leq$ 0.0, it is necessary that

$$\Delta t_A \geq 1/\omega$$

If AL(2) > 0.0, this condition should also be met; otherwise, the data generated will be meaningless. That is, the time interval for analysis must be greater than or equal to the time for one complete revolution of the appropriate rotor. However, it is not necessary that Δt_A be an integer multiple of $1/\omega$.

The analysis computes a function of amplitude versus frequency, $A(k\omega)$, for each of the NVARA variables whose code numbers are input on CARD 52 discussed below. In the analysis, each variable is assumed to be a function of time, $f(t)$.

$$f(t) = a_o + \sum_{k=1}^{N} [a_k \cos(2\pi k\omega t) + b_k \sin(2\pi k\omega t)]$$

The summation variable N is defined as

$$N = [(n-1)/2] + 1$$

where n equals the number of time points in the Δt_A interval or 2000, whichever is smaller. The brackets ([ ]) in the equation for N indicate that the enclosed term is truncated to be an integer. The amplitude function is then

$$A(k\omega) = \sqrt{a_k^2 + b_k^2}$$

NVARB controls the output of $A(k\omega)$. If NVARB = 0, the data are tabulated on the printer only; if NVARB = 1, the data are stored on magnetic tape for CALCOMP plotting (use type 10357, centimeter paper); if NVARB = 2, the data are both tabulated on the printer and stored on tape.

CARD 52

This card contains the code numbers of the variables to be analyzed. A total of NVARA code numbers must be included in 14I5 format, up to a total of 14. If more than 14 variables are to be harmonically analyzed, repeat CARDs 51 and 52 for those variables.

5.6 VECTOR ANALYSIS OF TIME-HISTORY DATA

When time-history data are available, the 60-series cards may be used to perform a vector analysis of selected variables. This procedure is an option that uses the technique of least-squared-errors curve fitting. If it is not to be used, simply omit the 60-series cards. Consult your local programmer for proper setup of jobs that write a tape for CALCOMP plotting. Refer to Section 9 for the code numbers discussed below.

CARD 61

Columns 1 and 2 must contain the integer 11 to call the curve-fitting routine. This procedure has three possible steps to it. The first step must be performed if either the second or third step is to be performed. The second and third steps are independent of each other, and each is optional.

Step 1:

Initially, the time histories, f(t), of the NVARA curves whose code numbers are given on the 62-type cards are curve fit to the equation

$$f(t) = A + B \sin(\omega t + \phi)$$

where ω is the baseline frequency, AL(1), and A, B, and ϕ are the constant, amplitude, and phase angle to be computed. This step will yield NVARA sets of A, B, and ϕ values. Permissible values of NVARA are 1 to 100.

Step 2:

Next, the amplitudes and phase angles computed in Step 1 may be compared to each other. The values computed are

$$R_B = B_i/B_x = \text{amplitude ratio}$$

$$R_\phi = \phi_i - \phi_x = \text{phase-angle difference}$$

where the subscript x indicates one of the NVARB reference variables and the subscript i indicates one of the NX variables that is to be compared to that reference value. The code numbers are input on 63-type cards. Note that only those code numbers used in Step 1 can be used in Step 2 and that the code number of a reference variable must not be included in the corresponding NX code numbers. Step 2 may be bypassed by setting NVARB = 0 and omitting all 63-type cards. Permissible values of NVARB and NX are 0 to 100.

Step 3:

The curve fits from Step 1 can themselves be fitted to an equation of the following form:

$$C = KD*D + DE*E + F$$

where C, D, and E are the f(t) corresponding to the three code numbers input on 64-type cards. Substituting each f(t) into the above equation, expanding the $\sin(\omega t + \phi)$ term to $(\sin\omega t \cos\phi + \cos\omega t \sin\phi)$, and equating the coefficients of like harmonics yields three equations in the three unknowns of KD, KE, and F. The equations are solved, and the three computed constants are output.

Since AL(2) of the 64-type cards must be included, AL(2) curve fits of the coefficients from Step 1 will be made. Note that, as in Step 2, only code numbers (variables) used in Step 1 can be used in Step 3. This step may be bypassed by setting AL(2) = 0.0 and omitting all 64-type cards. Permissible values of AL(2) = 0.0 to 100.

CARDS 62A, 62B, etc.

The 62-type cards contain the NVARA code numbers for the variables to be curve fit by Step 1. Up to 14 code numbers may be input on each card in integer fields of 5 (14I5 format).

The first column of all but the last 62-type card must be blank. An alphanumeric character must be placed in column 1 of the last 62-type card.

CARDS 63A, 63B, etc.

NVARB sets of the 63-type card must be included. Each set contains a code number for a reference variable plus the quantity (NX) and code numbers of the other variables to be used in Step 2. Each card is in 14I5 format.

The first column of all but the last 63-type card must be blank. An alphameric character must be placed in column 1 of the last 63-type card.

CARDS 64A, 64B, etc.

AL(2) cards of the 64-type must be included. These cards contain the code numbers of the variables to be used in Step 3.

The first column of all but the last 64-type card must be blank. An alphameric character must be placed in Column 1 of the last 64-type card.

5.7 TABULATION AND CONTOUR PLOTS OF SELECTED ROTOR VARIABLES

When IPL(79) $\neq$ 0, the values of 23 rotor variables are stored as functions of blade radius and azimuth location during quasi-static trim. These same data items are always stored during time-variant trim and maneuver. The 70-series cards are then used to select which of these 23 variables are to be presented as tabulations and contour plots in the printed output.

CARD 71

Columns 1 and 2 must contain the integer 12 to call the tabulation and contour plot routine. If the user wishes to tabulate the data, a 1 should be placed in Column 6. In like manner, the contour plots are activated by placing a 1 in Column 10.

Columns 11 through 15 contain the rotor identification number, which is only used for a PDB resulting from a quasti-static trim or a maneuver with two rotors modelled. The PDB resulting from a time-variant trim will only contain data for the rotor trimmed, and this variable is ignored when processing such a PDB.

The time in the time history at which data tabulations and/or plots are to begin is specified in Columns 21-25. This input is ignored for PDBs created by a quasi-static trim. The default value is the start time of the PDB.

CARDS 72A, 72B, etc.

These cards contain the code numbers for the variables that are to be tabulated and/or plotted. The code numbers are defined in Table 21 and are integer (right-justified) inputs. There should be no blank fields on the 72-type cards, except on the last such card after the last variable number.

All but the last 72-type cards must have card Column 1 blank, while an alphanumeric character must appear in the first column of the last 72-type card.

CAUTION: This option can generate large amounts of output. Each contour plot requires one printed page and each tabulation requires one or two printed pages. Hence, if data for all 23 variables are both printed and plotted, the output for this option alone will be 23 to 69 pages.

T BLE 22. CODE NUMBERS FOR ROTOR CONTOUR PLOTS

Code Number	Variable	Units
1	Mach number	-
2	Angle of attack	deg
3	Total lift coefficient	-
4	Unsteady lift coefficient increment*	-
5	Normal force coefficient	-
6	Drag coefficient	-
7	Chordwise force coefficient	-
8	Total pitching moment coefficient	-
9	Unsteady pitching moment coefficient increment*	-
10	Lift distribution ($q\ c_l\ c$)	lb_f/ft
11	Drag distribution ($q\ c_d\ c$)	lb_f/ft
12	Pitching moment distribution ($q\ c_m\ c^2$)	ft-lb_f/ft
13	Torque distribution	ft-lb_f/ft
14	Inflow angle	deg
15	Geometric pitch angle	deg
16	Induced velocity	ft/sec
17	Inflow velocity	ft/sec
18	Tangential velocity	ft/sec
19	Radial velocity	ft/sec
20	Yawed flow angle	deg

TABLE 22. Concluded

Code Number	Variable	Units
21	Out-of-plane displacement	ft
22	Inplane displacement	ft
23	Torsional displacement	deg
24	Currently unused	
25		

*In trim, only available when both time-variant rotor analysis and unsteady aerodynamics are active. In maneuver, only available when unsteady aerodynamics are active.

5.8 STABILITY ANALYSIS USING PRONY'S METHOD

The stability of any of the time-history variables listed in Section 9 can be examined by Prony's method. The use of this analysis is controlled by the 80-series cards, which must be omitted if this option is not to be invoked.

CARD 81

Columns 1 and 2 must contain the number 13 to use this stability analysis.

A printer plot of the actual waveform analyzed and the waveform synthesized from the Prony results will be produced if NPRINT $\neq$ 0.

CARDs 82A, 82B, etc.

All except the last of these cards must have card Column 1 blank. The last 82-type card must have some alphanumeric character in card Column 1 (a slash is recommended).

If the digit in Column 5 is zero or 1, the output frequency is normalized on the RPM of Rotor 1, while the output is normalized on the Rotor 2 RPM if Column 5 contains a 2.

The variable numbers are given in Section 9. The code number must be right-justified in the field.

Up to 40 terms can be used in the curve fit of the values of the variable between the start and stop time.

If the user is analyzing a long time history, every KSKIPth point of the time history may be skipped to reduce storage requirements.

The Prony analysis will be applied to the time-history data between TSTART and TSTOP.

The user can override the automatic scaling routine of the printer plot by inputting a non-zero value for SC1.

See Section 13 of Volume 1 of Reference 1 for a detailed description of this stability analysis.

5.9 CREATION OF A DATA TRANSFER FILE (DTF)

Data in a Postprocessing Data Block (PDB) may be transferred to the Master File (accessed by the DATAMAP programs) using the NPART = 15 option of GDAP80. (The DATAMAP programs are described in detail in Reference 2.) The user is reminded that it is pointless to transfer data items to the Master File unless meaningful data were generated by the AGAP80 case which created the PDB. If both C81 and DATAMAP have been installed in the normal manner, the DTF created using this option of GDAP80 will automatically be processed by the DATAMAP File Creation Program and the data added to the appropriate partition on the Master File. Check with your local programmer to determine the manner in which these programs have been interconnected at your installation.

CARD 91

This card must contain the integer number 15 in the first two card columns to invoke the DTF-creation option.

Card columns 3 through 6 contain a right-justified integer, NPRINT, denoting the number of cards containing DATAMAP File Creation Program (FCP) instructions that will be input. This input must be non-zero for the first invocation of this option, as several instructions must be input. The number must be zero for all subsequent NPART = 15 instruction sets because no further instructions can be input.

Card columns 7 through 10 contain a right-justified integer number, NSCALE, which denotes the number of Generated Data Group names that will be input. This number should be between 0 and 22 inclusively.

A blank or zero input in card column 15 will cause the DTF to be generated in internal format, while a non-zero input will result in a DTF in external format. External format must be selected whenever C81 is run on one model of computer and DATAMAP is run on a different model.

CARDs 92A, 92B, etc.

These cards contain instructions for the DATAMAP File Creation Program. (The user is referred to Reference 2 for specific instruction in the use of the FCP.) Typical instructions would be NEW, USER, and RATE. The FCP instructions must also include the partition name and password. The instructions are to be input to GDAP80 in free format in the first 60 columns of each card. See Figure 41 for an example.

```
14
 3   1
  353  360  320    1                                            200.0
  367  374  320    1                                            200.0
  381  388  320    1                                            200.0
  395  402  320    1                                            200.0
  409 1508  320    1                                            200.0
 1509 1510  320    1                                            200.0
/1511  320         1                                  200.0
 9              13      .925 1.296    0                 0
/ 353  360  367  374   381  388   395   402   409 1508 1509 1510 1511
12   1    1    1        1.111
/    1    2
15   5    3
ADD SAMPLPRT PASS AUSTIN
SPACE 9999 USER VG
RATE 256 RECORD 1.296
ALL ITEMS ALL COUNTERS
END
 BBM1 CBM1 TBM1
/ 133  144  154   173   233   234   235   244   253   262   271   321
```

First invocation of NPART = 15

```
14
 3   1
  353  360  320    1                                            200.0
  367  374  320    1                                            200.0
  381  388  320    1                                            200.0
  395  402  320    1                                            200.0
  409 1508  320    1                                            200.0
 1509 1510  320    1                                            200.0
/1511  320         1                                  200.0
 9              13      .925 1.296    0                 0
/ 353  360  367  374   381  388   395   402   409 1508 1509 1510 1511
15   0    3
 BBM1 CBM1 TBM1
/ 133  144  154   173   233   234   235   244   253   262   271   321
```

Subsequent NPART = 15 invocation

```
14
 3   1
  353  360  320    1                                            200.0
  367  374  320    1                                            200.0
  381  388  320    1                                            200.0
  395  402  320    1                                            200.0
  409 1508  320    1                                            200.0
 1509 1510  320    1                                            200.0
/1511  320         1                                  200.0
 9              13      .925 1.296    0                 0
/ 353  360  367  374   381  388   395   402   409 1508 1509 1510 1511
15   0    3
 BBM1 CBM1 TBM1
/ 133  144  154   173   233   234   235   244   253   262   271   321
```

Subsequent NPART = 15 invocation

Figure 41. Example Input for Data Transfer File Creation

CARDs 93A, 93B

If NSCALE is zero (or blank), then the 93-type cards must not be included in the deck.

These cards contain up to 22 Generated Data Group names. Each name is used to automatically include the time histories of a particular type of data in the Data Transfer File. The four-character names are listed in Table 22 and must be right-justified in five-column fields. For example, invoking the Generated Data Group name BBM1 includes all Rotor 1, Blade 1, beam bending moment time histories in the Data Transfer File. GDAP80 will read exactly NSCALE names and the program assumes that there will be no blank fields in the list of names input on these cards. CARD 93B should be included only if more than 14 names are to be input.

If no individual item codes are to be input on the 94-type cards, then CARD 93A (CARD 93B if it is used) must have some alphanumeric character in card column 1 to signify the end of the NPART = 15 inputs.

CARDs 94A, 94B, etc.

The last 94-type card is indicated by any non-blank character in the first card column.

The item codes for individual data items to be included in the DTF are input on the 94-type cards. These item codes are right-justified in five-column fields, with blank fields occurring only after the last item code. Table 28 (Section 9) contains the item codes for all variables stored during time-variant trim and maneuver.

The item codes for the azimuth angle time histories of each rotor (320 and 333) are automatically included in the list of item codes, and the user must not input these two item codes. Additionally, the user must not input the item codes of any of the variables included in the Generated Data Sets selected on the 93-type cards. A maximum of 507 items, including both those requested on the 94-type cards and those specified in the Generated Data Sets, may be included in a Data Transfer file.

TABLE 23. GENERATED DATA GROUP NAMES

Data Type	Rotor 1	Rotor 2
Beam Bending Moment	BBM1	BBM2
Chord Bending Moment	CBM1	CBM2
Torsional Bending Moment	TBM1	TBM2
Blade Element Lift Coefficient	CLR1	CLR2
Blade Element Normal Force Coefficient	CNR1	CNR2
Blade Element Drag Coefficient	CDR1	CDR2
Blade Element Chord Force Coefficient	CCR1	CCR2
Blade Element Pitching Moment Coefficient	CMR1	CMR2
Blade Element Running Lift	LFR1	LFR2
Blade Element Running Drag	DFR1	DFR2
Blade Element Running Pitching Moment	PFR1	PFR2

The use of one or more of these names on a 93-type card automatically includes the time-histories of that type of data for Blade 1 of the particular rotor in the DTF.

6. OUTPUT GUIDE FOR AGAP80

The output available to be printed is divided into the several groups listed in Table 24, with a statement as to when each group will, will not, or may be printed. The sequence of the groups in the table corresponds to the sequence in which they are printed in the output and are discussed in this section. As the table indicates, not all groups will necessarily be printed during a particular run. The printout of most groups depends on the type of run (value of NPART), the type of data included in the input deck (elastic blade data, airfoil data tables, etc.), and the program options activated by the input data (time-variant trim, blade element data, etc.). The printout for each of the groups in Table 24 is discussed following a description of the reference systems and sign conventions used for the input and output data.

6.1 REFERENCE SYSTEMS

All of the basic analyses in C81 were developed and programmed in Cartesian coordinate systems. The coordinate systems that are of most importance to the user include the ground, fuselage, body, aerodynamic surface, rotorshaft, rotor analysis, and wind reference (or axis) systems. Each reference system is oriented with respect to one or more of the other systems by a set of ordered angular rotations.

C81 uses Euler angles to orient the body reference system with respect to the ground reference (see Figure 42). Both reference systems are right-handed coordinate systems with positive rotations defined by the right-hand rule. Hence, the three rotations in order are:

(1) Psi (ψ): a positive rotation about the ground reference Z axis - a yaw rotation.

(2) Theta (θ): a positive rotation about the Y axis, which has been previously oriented through the ψ rotation - a pitch rotation.

(3) Phi (Φ): a positive rotation about the X axis, which has been oriented by the ψ and θ rotations - a roll rotation.

Although all reference systems in C81 are oriented by ordered rotations, not all the ordered angles and their sign conventions are truly Euler angles. This point will be made clear in the following discussion of the seven reference systems mentioned above.

TABLE 24. OUTPUT GROUPS

Output Groups	Value of NPART 1	2	4	5	7	8	10
Input Data							
Data Deck Listing	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Problem Identification	Norm	Norm	Norm	Norm	Norm	Norm	Norm
Basic Data Groups	Norm	Norm	Norm	No	Norm	No	Norm
Elastic Blade Data	(A)	(A)	(A)	No	(A)	No	No
Check of Aerodynamic Inputs	(B)	(B)	(B)	No	(B)	No	(B)
Accelerated Flight Conditions	Yes	Yes	Yes	No	Yes	No	Yes
Maneuver Specification	No	Norm	Norm	Norm	No	No	No
Airfoil, RIVD, RWAS Data Tables	(A)	(A)	(A)	No	(A)	No	No
Trim Iteration Page(s)	Norm	Norm	Norm	No	Norm	No	Yes
Standard Trim Page	Yes	Yes	Yes	No	Yes	No	Yes
Optional Trim Page	(C)	(C)	(C)	No	(C)	No	(C)
Time-Variant Trim Data	(C)	(C)	(C)	No	No	No	(C)
Maneuver-Time-Point Printout							
External Store Drop	No	(C)	(C)	(C)	No	No	No
Time-Point Page(s)	No	Norm	Norm	Norm	No	No	No
Rotor Elastic Response	No	(D)	(D)	(D)	No	No	No

Yes: The group is always printed for specified value of NPART.
No : The group is never printed for specified value of NPART.
Norm: The group is normally printed, but can be suppressed by appropriate input values.
(A) : The group is printed only if the corresponding data block(s) or table(s) is input; printout can be suppressed.
(B) : The group is printed only if errors are detected in the aerodynamic inputs.
(C) : The group is printed only if the corresponding operation or option is called for by input data.
(D) : The group is printed only if elastic blade data are available.

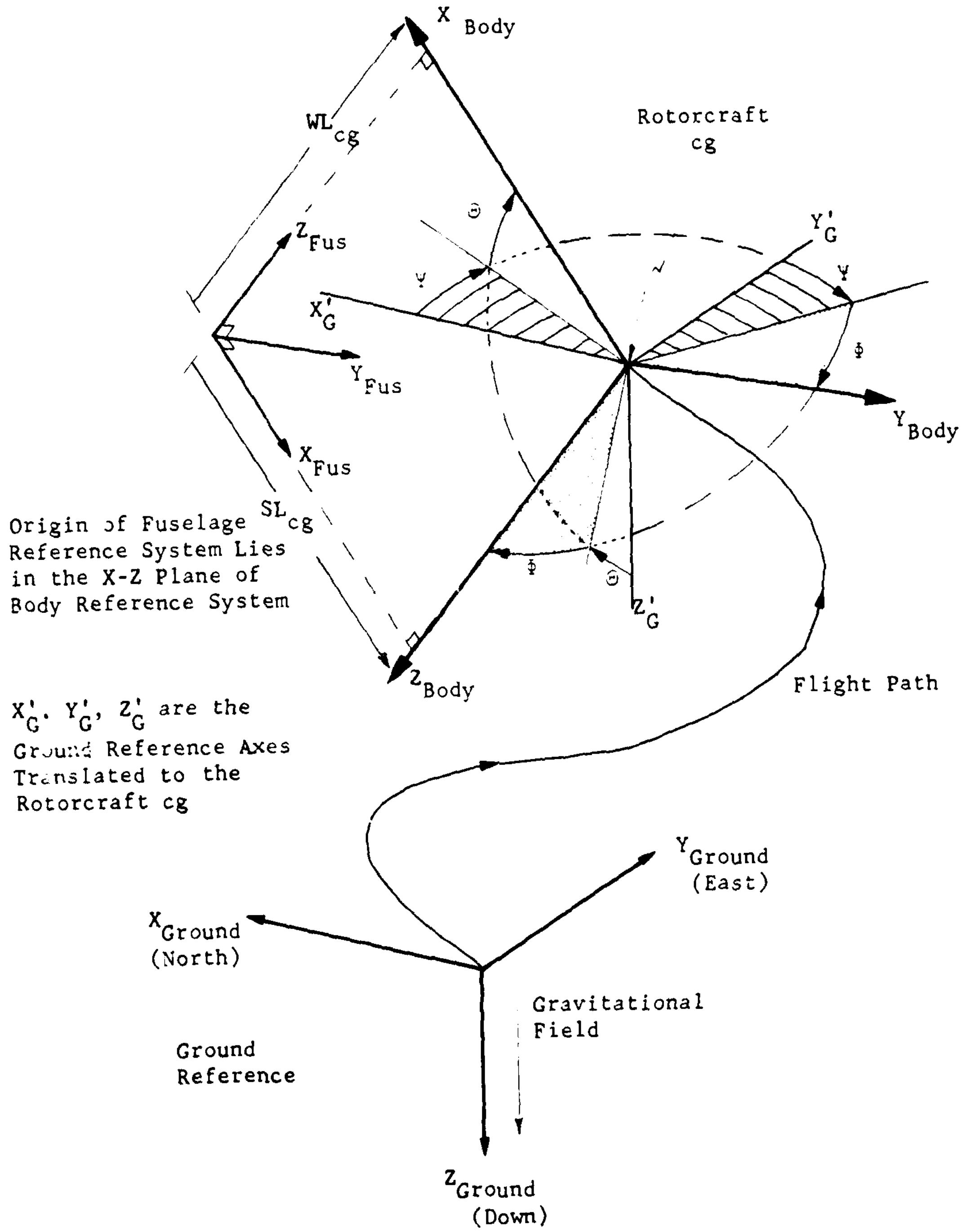


Figure 42. Relationship of Ground, Body, and Fuselage Reference Systems.

6.1.1 Ground Reference System

The C81 Ground Reference System, a right-handed coordinate system, is fixed to the surface of a flat earth with its Z axis pointing down through the center of the gravitational field, its X axis pointing due north, and its Y axis pointing due east. In C81 the gravitational constant is defined to be 32.1725 feet per second squared. During trim and at time zero of all maneuvers, the ground reference X and Y coordinates of the rotorcraft center of gravity are zero, and the Z coordinate is the negative of the geometric altitude.

6.1.2 Fuselage Reference System

The C81 input format uses the Fuselage Reference System, a right-handed coordinate system, to define the locations of components or properties on the rotorcraft, e.g., the shaft pivot point, the center of gravity, and centers of pressure for the aerodynamic surfaces. As its name implies, this system is fixed with respect to the structure of the rotorcraft. The system is equivalent to the conventional stationline-buttline-waterline (SBW) coordinate system used in the design of most aircraft. The location of its origin is arbitrary. However, for AGAP80, it must lie in the vertical plane of symmetry of the fuselage if certain program features such as locating the jets and orienting aerodynamic surfaces are to work properly.

In the Fuselage (SBW) Reference System, the X (stationline) axis is positive aft, the Y (buttline) axis is positive to starboard and the Z axis is positive toward the top of the airframe. X, Y, and Z coordinates (stationlines, buttlines, and waterlines) are defined to be in inches from the origin. This reference system is used only for input data.

6.1.3 Body Reference System

The Body Reference System, a right-handed coordinate system, is the primary reference system in C81. It is the reference system in which total rotorcraft forces and moments are summed during both trim and maneuver and is the system in which the rotorcraft stability analysis equations were derived. The origin of the system is defined to be at the rotorcraft cg, which is located by X, Y, and Z coordinates in the Ground Reference System. The axes of the system are oriented with respect to the Ground Reference System by Euler rotations of ψ, θ, and Φ as discussed previously.

If the Fuselage Reference System is rotated 180 degrees about its Y axis, and its origin moved to the rotorcraft cg, the rotated and translated system is defined to be coincident with

the Body Reference System. Hence, the Y axes of both the Fuselage and Body Reference Systems are positive to starboard, while the Body Reference X axis is positive forward and the Z axis is positive toward the bottom of the rotorcraft.

As with the Fuselage Reference System, the Body Reference System is fixed with respect to the structure of the rigid body rotorcraft. During trim, the system may rotate with respect to the Ground Reference System and during maneuvers it may translate as well. The relationships between the Ground, Fuselage, and Body Reference Systems are shown in Figure 42. If the cg location is recomputed prior to trim or during maneuver bacause of store input or drop(s), the origin of the Body Reference System moves to the new cg location. Moment arms from the cg to the rotor hubs, wing, etc., are recomputed each time the cg moves.

6.1.4 Aerodynamic Surface Reference System

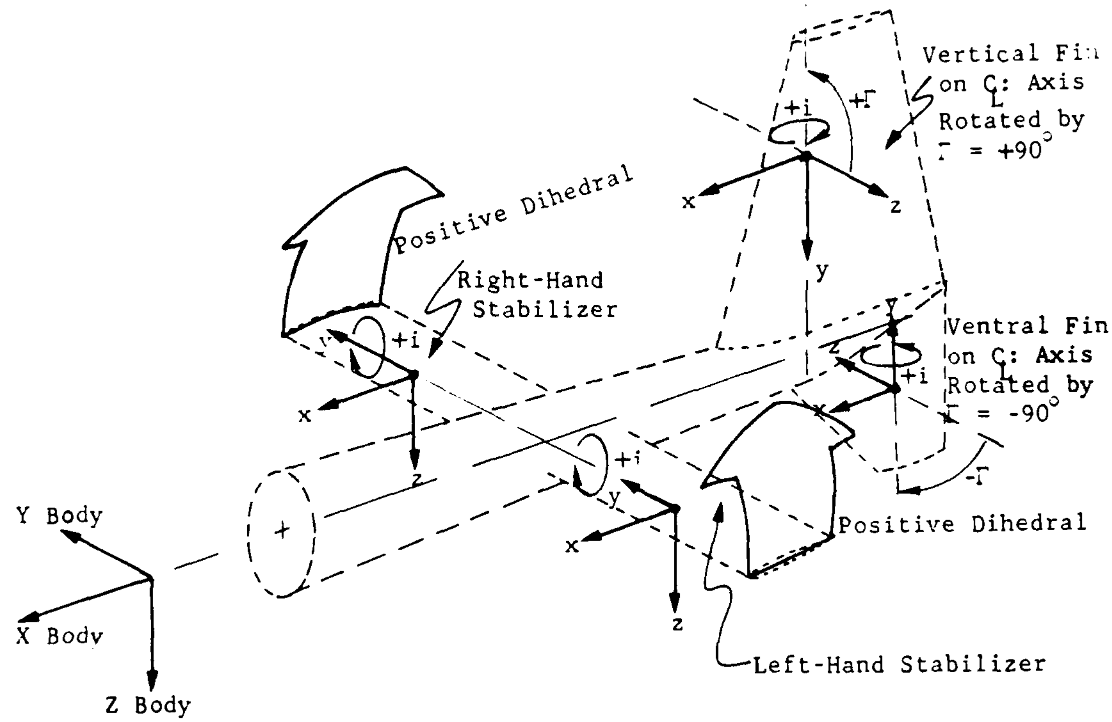
Each wing panel and each of the four stabilizing surfaces uses a separate Aerodynamic Surface Reference System to define the orientation of that surface's axis of incidence change and the incidence angle. Each system is a right-handed coordinate system with its origin at the center of pressure of the appropriate surface. The orientation of each system is defined with respect to the body axis by two ordered rotations:

(1) Γ: dihedral angle rotation and

(2) i: a positive rotation about the Y axis, which has been previously rotated through Γ - an incidence rotation.

Dihedral angle, Γ, is always defined to be positive in the direction that displaces the outboard tip of a surface upward with respect to a Fuselage Reference System X - Y plane. That is, for a surface whose center of pressure is on or to the left of the fuselage plane of symmetry (buttline ≤ 0), positive dihedral is a right-handed rotation about the body X axis. If the center of pressure is to the right (buttline > 0), positive dihedral angle is a left-handed rotation. The implications of these definitions are that horizontal stabilizing surfaces with dihedral or anhedral should be modeled as two separate surfaces. A vertical fin with its center of pressure at or to the left of buttline 0.0 should be considered to have a +90-degree dihedral angle.

Positive incidence is always defined as a right-handed rotation about the Y axis of the aerodynamic reference system. Hence, the Y axis and the axis of incidence change are coincident. The relationship of the Body and Aerodynamic Surface Reference Systems is shown in Figure 43.



SURFACE	WING AND HORIZONTAL STABILIZERS		VERTICAL AND VENTRAL FINS	
CP Location	Dihedral: Γ	Incidence	Dihedral: Γ	Incidence
Buttline > 0 (Rt of C_L)	< + 90 > - 90	+ L.E. UP + L.E. UP	+90 -90	+ L.E. Left + L.E. Right
Buttline $\leq$ 0 (ON or LT of C_L)	< + 90 > - 90	+ L.E. UP + L.E. UP	+90 -90	+ L.E. Right + L.E. Left

Figure 43. Relationship of Body and Aerodynamic Surface Reference Systems.

The orientation of the Y axis and the origin of each system are fixed with respect to the Body Reference System during all trims and maneuvers, but the control linkages can rotate each system about its Y axis.

6.1.5 Rotor Shaft Reference System

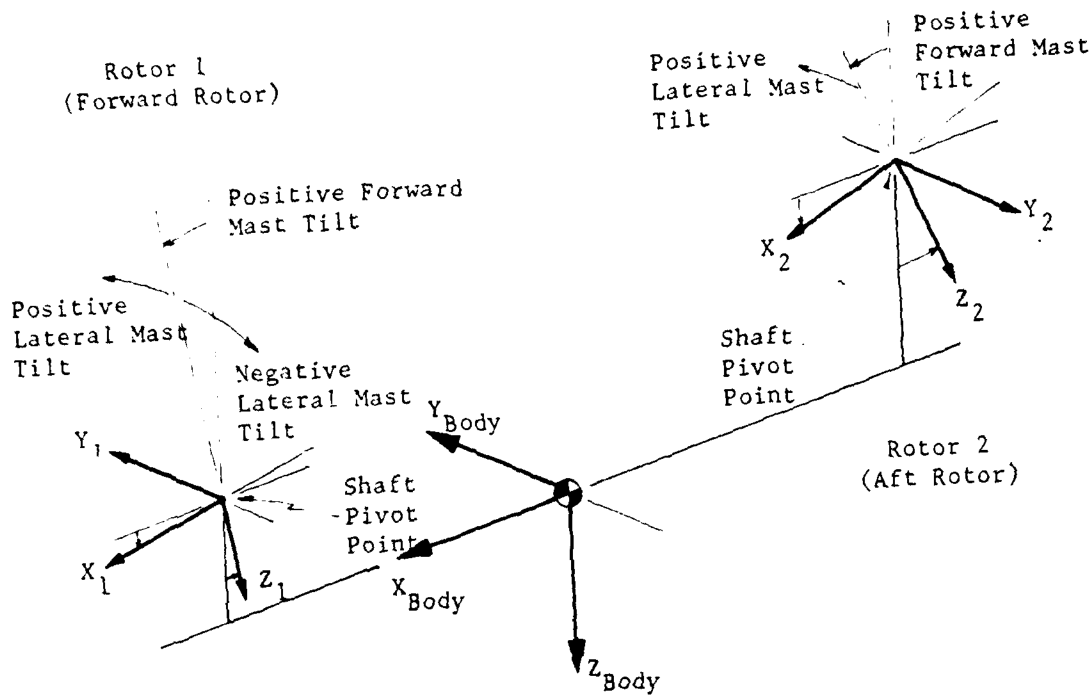
The program uses two independent Rotor Shaft Reference Systems, one for each rotor. The origin of each system is at the shaft pivot point of its respective rotor, and, as noted earlier, the Rotor 1 Shaft Reference System is a right-handed coordinate system, while the Rotor 2 system is left-handed. Each system is oriented with respect to the Body Reference System by ordered rotations through the longitudinal mast tilt angle and lateral mast tilt angle.

The most convenient means of describing the positive directions of the rotations is to say that positive mast tilt angles will tilt the rotor shaft forward and then to the right for both rotors. Hence, if all four mast angles are zero, the X and Z axes of both Rotor Shaft Reference Systems and the Body Reference System are parallel and point in the same direction. However, the Y axis of the Rotor 2 Shaft Reference System points in the opposite direction of the other two Y axes. The origins of both Rotor Shaft Reference Systems are fixed with respect to the Body Reference System during both trim and maneuver. The orientation is fixed during trim, but the longitudinal mast tilt angle can be changed during a maneuver, which does reorient the system.

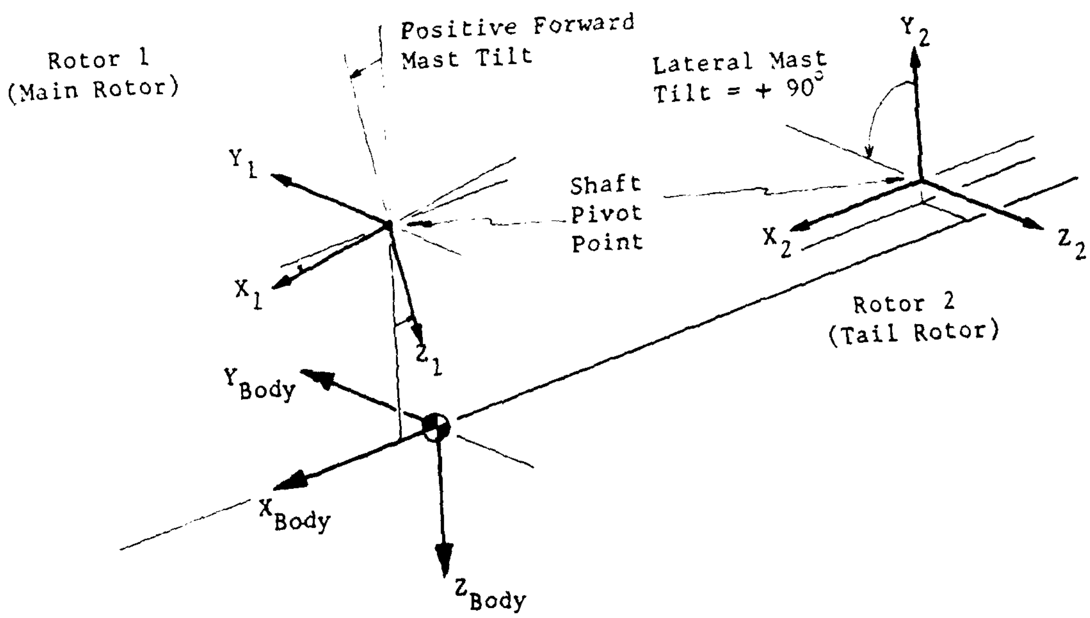
Note that if the longitudinal mast tilt angle changes in maneuver, and the lateral mast tilt is nonzero, the longitudinal rotation will be about the body reference Y axis, not the shaft reference Y axis. That is, at each time point the orientation is determined by the two ordered rotations from the Body Reference System, not by one rotation from the initial Shaft Reference orientation. Figure 44 shows the relationship of the two Rotor Shaft Reference Systems to the Body Reference System.

6.1.6 Rotor Analysis Reference Systems

The program uses two independent Rotor Analysis Reference Systems: the system for Rotor 1 is oriented with respect to the Rotor 1 Shaft Reference System and the system for Rotor 2 with respect to the Rotor 2 Shaft Reference System. The origin of each system is located at the hub of its respective rotor; i.e., the Rotor Shaft Reference System X and Y coordinates of the origin of the Rotor Analysis Reference System are zero and the Z coordinate is the negative of the mast length. The Rotor Analysis Reference Systems are oriented with respect to



(a) Tandem-Rotor Configuration.



(b) Single-Main-Rotor Configuration.

Figure 44. Relationship of Body and Shaft Reference Systems.

the Rotor Shaft Reference System by a single rotation about the shaft reference Z axis. This angle is the rigid body azimuth angle of the blade being analyzed. Hence, the Rotor Analysis Reference Systems are rotating reference systems with respect to the Rotor Shaft and Body Reference Systems. For Rotor 1 the right-handed rotation vector points up (negative Z direction) and for Rotor 2 the left-handed rotation vector points up (negative Z direction). Figure 45 shows the relationship of the Rotor Analysis Reference Systems to the Rotor Shaft Reference Systems.

6.1.7 Wind Reference Systems

All aerodynamic loads are computed in the Wind Reference System. By definition, a Wind Reference System only has a velocity component along its X axis; the Y and Z velocities are identically zero. Since the local flow at each rotorcraft component on which aerodynamic forces and moment act is normally not parallel to the flightpath velocity vector, separate reference systems are defined for each component. The origin of each of the Local Wind Reference Systems is at the center of pressure or aerodynamic data reference point of each component. Each system is oriented with respect to the corresponding component system (e.g., Body, Aerodynamic Surface, and Rotor Shaft Reference Systems) by one of two possible sets of two ordered rotations. The first set of possible angles corresponds to angles commonly measured in flight test:

(1) Negative Beta ($-\beta$): a rotation (equal to the negative of the sideslip angle β) about the component Z axis, and

(2) Negative Alpha ($-\alpha$): a rotation (equal to the negative of the angle of attack α) about the component Y axis, which has been rotated through $-\beta$ previously, where $\alpha = \alpha_{wind}$.

The second set corresponds to angles commonly measured in wind tunnel tests and are a set of inverse Euler angles with roll deleted:

(1) Negative Aerodynamic Pitch Angle ($-\theta_W$): a rotation (equal to the negative of θ_W) about the component Y axis, and

(2) Negative Aerodynamic Yaw Angle ($-\psi_W$): a rotation (equal to the negative of ψ_W) about the Z axis, which has been rotated through $-\theta_W$ previously.

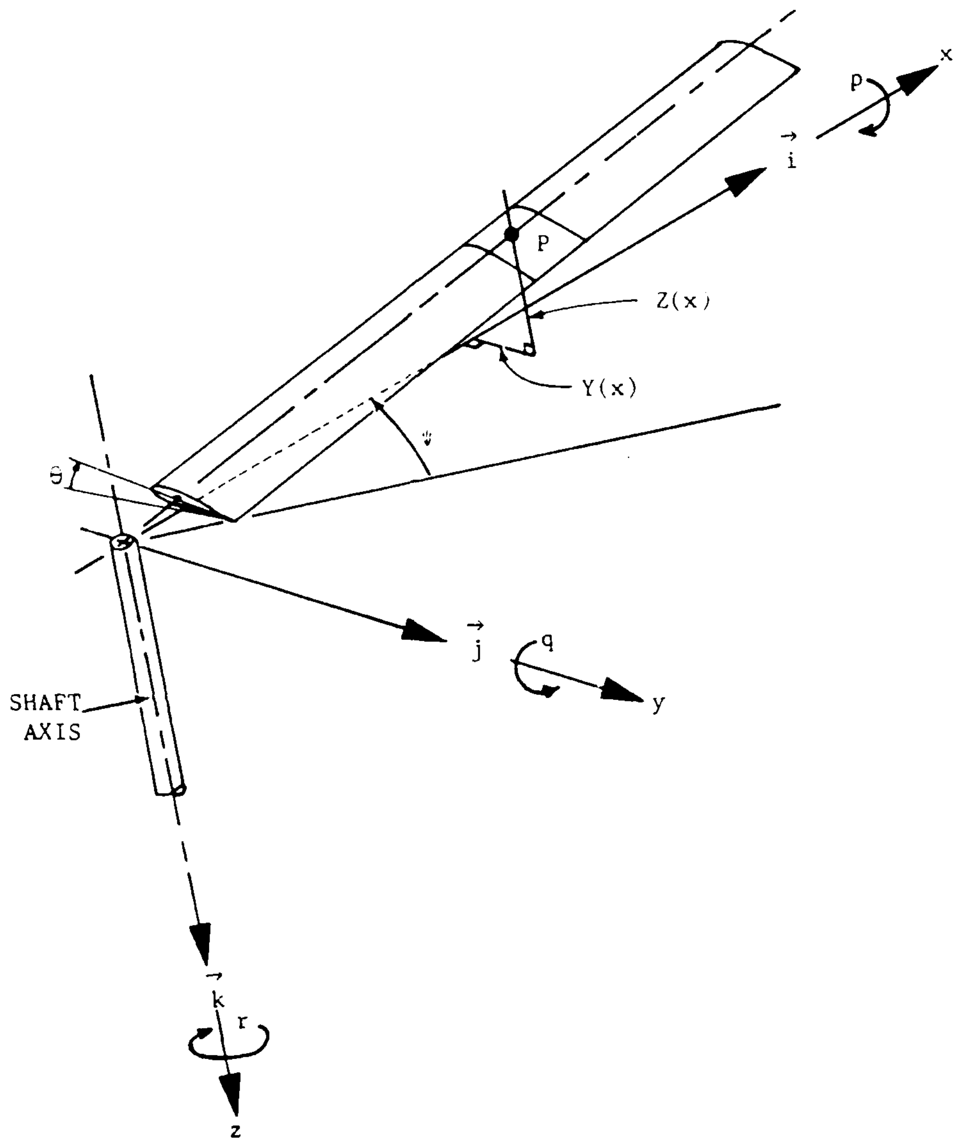


Figure 45. Reference System for Rotor Analysis.

Each of these four angles is defined by trigonometric functions of X, Y, and Z velocities in the component reference system. The definitions of α_{wind} and θ_w are identical, and the two angles can be used interchangeably. However, β and ψ_w are not identical. See Figure 46 and Section 6.2.3.2 for the definitions of these angles.

Orientation of a Wind Reference System with respect to ground reference only is meaningless and cannot be defined. The orientation of the wind vector, and hence the X axis of a Wind Reference System, can be defined by two Euler-type angles; i.e., azimuth (yaw) and elevation (pitch). However, the orientation of the Y and Z axes about the X axis cannot be defined without referring to one of the rotorcraft component reference systems. This situation does not limit any analysis or computation since the point of interest is the action of the air mass on a component, not the ground.

6.2 SIGN CONVENTIONS

The sign conventions of the most commonly used rotor-related parameters are summarized in Table 25. The conventions listed are for the condition where both rotor shafts are vertical (i.e., a tandem or side-by-side rotor helicopter) and are stated in terms of pilot reference. For nonvertical shaft(s), the rotor-related sign conventions remain unchanged with respect to the Rotor Shaft Reference System. Table 26 gives the rotor designation and sign conventions for four standard rotorcraft configurations.

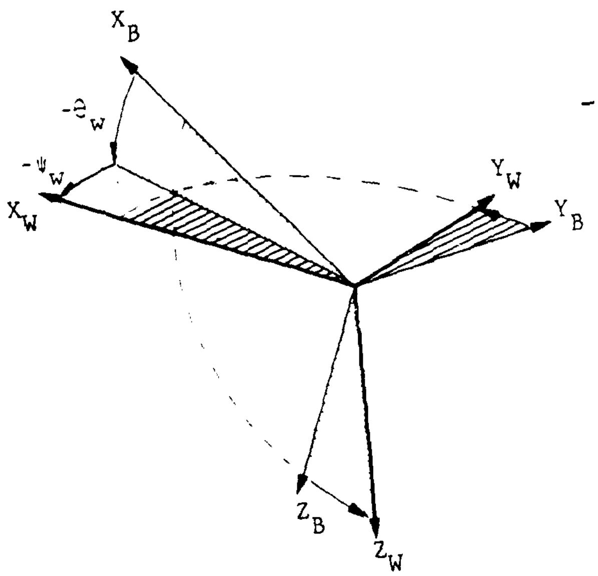
Additional discussion of some of these rotor-related parameters and parameters mentioned in Section 6.1 is included below.

6.2.1 Rotor Flapping and Elastic Displacements

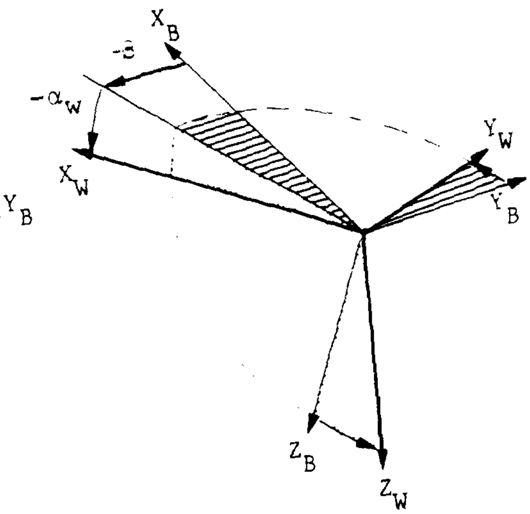
Rotor flapping can be defined with respect to either the Rotor Analysis or Rotor Shaft Reference System of the appropriate rotor. Shaft reference flapping is divided into a longitudinal and a lateral component. Rotor Analysis Reference System flapping (instantaneous value of flapping) is based on the out-of-plane displacement of the blade tip for the first mode (rigid body mode) of the rotor at a particular azimuth angle. If coning is neglected,

$$\beta(\psi) = -a_1 \cos \psi - b_1 \sin \psi$$

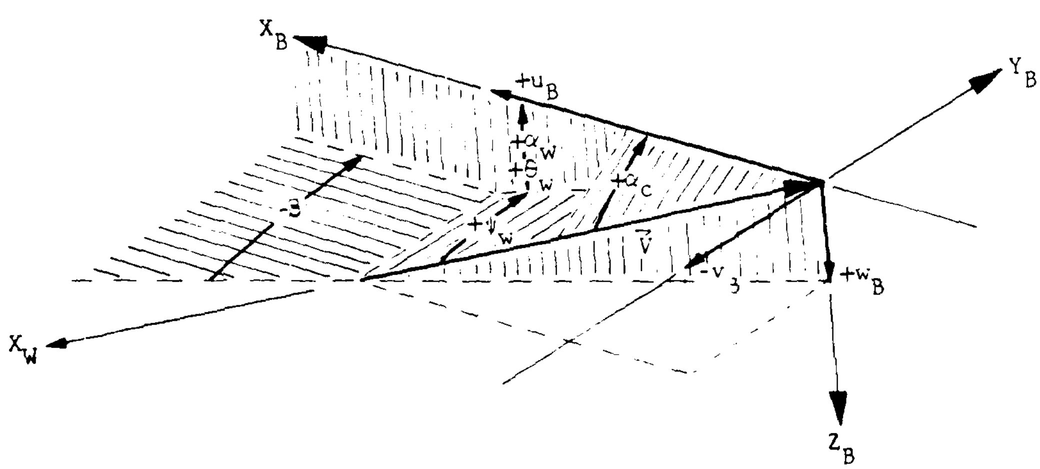
B = Body
W = Wind



(a) Rotations With Wind Tunnel Angles.



(b) Rotations With Flight Test Angles.



(c) Planes in Which Angles Are Measured.

Figure 46. Relationship of Wind and Body (Component) Reference Systems.

TABLE 25. SIGN CONVENTIONS FOR ROTOR RELATED PARAMETERS

Parameter	Positive Direction of Parameter Rotor 1	Rotor 2
Shaft Reference System (origin at shaft pivot point)		
X-Axis	Forward	Forward
Y-Axis	Right	Left
Z-Axis	Down	Down
Mast Tilt Angle		
Longitudinal $(\beta_m)_F$	Forward	Forward
Lateral $(\beta_m)_L$	Right	Right
Swashplate Angles		
Longitudinal (B_1)	Forward	Forward
Lateral (A_1)	Down Right	Down Right
Control Phasing Angle (γ) (measured from the projection on the swashplate of the pitch-link attach point to the pitch horn)	In same direction as blade rotation	In same direction as blade rotation
Pylon Motions		
Longitudinal (a_F)	Forward	Forward
Lateral (a_L)	Right	Left
Direction of Rotor Rotation (as viewed from above)	Counterclockwise (right-handed rotation vector up)	Clockwise (left-handed rotation vector up)
Pitch-Flap Coupling Angle (δ_3) (measured from 90° ahead of blade feathering axis)	Opposite to direction of blade rotation	Opposite to direction of blade rotation
Shaft Axis Flapping		
Longitudinal (a_1)	Aft	Aft
Lateral (b_1)	Down Right	Down Left
Blade Rigid-Body Displacements		
Flapping (β)	Up	Up
Twist, Collective Pitch, and Feathering $(\theta_o, \theta_1,$ and $\theta_f)$	Blade leading edge up	Blade Leading edge up

TABLE 25. (Concluded)

Blade Elastic Displacements		
Out-of-Plane	Up	Up
Inplane	Opposite to direction of blade rotation	Opposite to direction of blade rotation
Torsion	Blade leading edge up	Blade leading edge up
Rotor Forces		
H-Force (H)	Aft	Aft
Y-Force (Y)	Right	Left
Thrust (T)	Up	Up

Assumptions used in making the above definitions:

(1) Both rotor shafts are vertical with respect to the Fuselage Reference System.

(2) Rotor hub is at or above shaft pivot point and pylon focal points.

(3) The directions are with respect to a forward-facing pilot.

TABLE 26. CONVENTIONS FOR SPECIFIC CONFIGURATIONS

	Single-Rotor Helicopter (KONFIG=1)	Tandem-Rotor Helicopter (KONFIG=2)	Prop-Rotor Aircraft (Helicopter Mode) (KONFIG = 3)	Prop-Rotor Aircraft (Airplane Mode) (KONFIG = 3)
Rotor 1				
Designation	MAIN	FORWARD	RIGHT	RIGHT
Thrust	Up	Up	Up	Forward
H-Force	Aft	Aft	Aft	Up
Y-Force	Right	Right	Right	Right
Rotor 2				
Designation	TAIL	AFT	LEFT	LEFT
Thrust	Right	Up	Up	Forward
H-Force	Aft	Aft	Aft	Up
Y-Force	*	Left	Left	Left

Directions noted are with respect to a forward-facing pilot

* Tail rotor Y-Force: + Up for + 90 lateral mast tilt
+ Down for -90 lateral mast tilt

For tail rotor lateral mast tilt of:

+ 90 : the blade above the rotor hub rotates toward the front of the helicopter
- 90 : the blade above the rotor hub rotates toward the rear of the helicopter

where

a_1 = longitudinal flapping angle (shaft reference)

b_1 = lateral flapping angle (shaft reference)

ψ = blade azimuth location

β = instantaneous value of flapping

The shaft reference flapping angles define the orientation of the rigid body tip path plane. However, they are not ordered rotations. The angles a_1 and b_1 are independent positive rotations about the shaft reference Y and X axes respectively as shown in Figure 47. Note that for Rotor 1 this means right-handed rotations about the right-handed coordinate system, while for Rotor 2 it means left-handed rotations about a left-handed system. Based on these definitions for a_1 and b_1, positive β (equivalent to positive out-of-plane displacement) is up the shaft (the negative Z direction).

When using the quasi-static rotor analysis, the rotor equations are solved in terms of a_1 and b_1. From these values, β can be calculated for any azimuth. However, when the time-variant rotor analysis is used, the value of β, not a_1 and b_1, is solved for at each azimuth location. Hence, with only a single azimuth location, a_1 and b_1 cannot be defined. In this case, the values of β at the current and previous four azimuth positions are used to solve the following equation in five unknowns:

$$\beta(\psi) = a_o - a_1 \cos \psi - b_1 \sin \psi - a_2 \cos 2\psi - b_2 \sin 2\psi$$

This method eliminates the steady and 2-per-rev components from the a_1 and b_1 time histories.

Positive inplane displacements of a point on a blade indicate that the blade is lagging behind the rigid body feathering axis. That is, the usual positive drag force produces a positive inplane displacement.

A positive torsional displacement twists the blade leading edge up with respect to the plane of rotation. This is the same direction as positive geometric twist, collective pitch, and cyclic feathering.

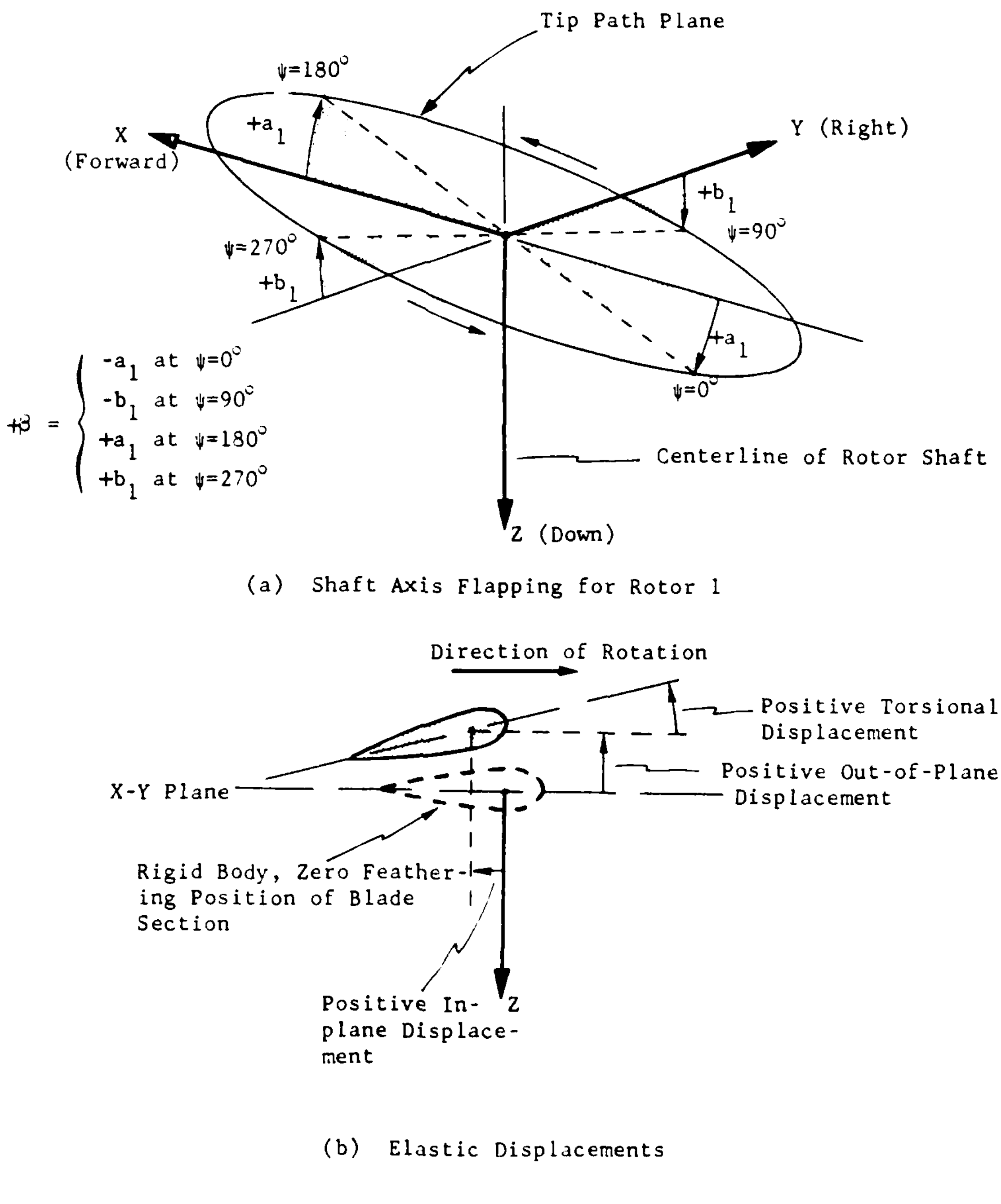


Figure 47. Blade Flapping and Elastic Displacement.

6.2.2 Control Positions

6.2.2.1 Position in Percent or Inches

6.2.2.1.1 Collective Stick

Zero percent collective stick is full down. Positive stick motion in percent or inches is upward.

6.2.2.1.2 Longitudinal Cyclic Stick

Zero percent longitudinal cyclic stick is full aft. Positive stick motion in percent or inches is forward.

6.2.2.1.3 Lateral Cyclic Stick

Zero percent lateral cyclic stick is full left. Positive stick motion in percent or inches is to the right.

6.2.2.1.4 Pedals

Zero percent pedal is full right. Positive pedal motion in percent or inches is to the left. That is, positive pedal tends to make the rotorcraft yaw nose left.

6.2.2.2 Positions in Radians or Degrees

When control positions are expressed in radians or degrees, these values correspond to the control angles computed from the basic rigging equations (see Table 18 in Section 4.20). Hence, they are the control angles without nonlinearities and control mixing. These units appear most frequently in the partial derivative matrix printed during trim iterations.

6.2.3 Miscellaneous Quantities

6.2.3.1 Climb and Heading Angles

The climb angle is the angle of the flightpath relative to the X-Y plane in ground reference. It is positive if the rotorcraft is climbing. The heading angle is the direction of the flightpath on the compass. Zero heading is due north, along the ground reference X axis. A heading of 90 degrees is due east.

6.2.3.2 Aerodynamic Angles

The Local Wind Reference Systems are oriented with respect to the Body, Rotor Shaft, or Aerodynamic Surface Reference Systems by what are referred to as aerodynamic angles (see Section 6.1.7). These angles are based on the components of velocity including gusts along the X, Y, and Z axes of the appropriate reference system.

$$\text{Pitch Angle of Attack, } \theta_w = \theta_{wind} = \tan^{-1} \frac{\text{Z velocity}}{\text{X velocity}} = \tan^{-1} \frac{w}{u}$$

if $u = w = 0$, $\theta_w = 0$ by definition

Yaw Angle of Attack (or Aerodynamic Yaw Angle) = ψ_w

$$= \sin^{-1} \left(\frac{\text{-Y velocity}}{\text{Total velocity}}\right) = \sin^{-1} \left(\frac{-v}{V}\right)$$

if $V = 0$, $\psi_w = 0$ by definition

$$\text{Angle of Sideslip} = \beta = \tan^{-1} \left(\frac{\text{Y velocity}}{\text{X velocity}}\right) = \tan^{-1} \left(\frac{v}{u}\right)$$

6.2.3.3 Gust Velocities

All gusts are defined with respect to the Body Reference System as follows:

(1) The forward component of gust velocity is positive if the gust is moving in the positive X direction.

(2) The lateral component of gust velocity is positive if the gust is moving in the positive Y direction.

(3) The vertical component of gust velocity is positive if the gust is moving in the positive Z direction.

6.2.3.4 Acceleration Levels in G

The acceleration levels in units of g are defined with respect to the Body Reference System as follows:

(1) Forward acceleration is positive, in the positive X direction.

(2) Positive lateral g level is to port, in the negative Y direction.

(3) Positive vertical g level is upward, in the negative Z direction. For straight and level flight, the vertical g level is 1.00.

6.3 OUTPUT GROUPS FOR INPUT DATA

6.3.1 Data Deck Listing (Figures 48 and 49)

Following the printout of the computer operating system information (JCL cards, run time, etc.), the message on the first card of the data deck, CARD 00, is printed six times on one page. This message is intended to instruct the computing control section as to the disposition of the printed output and card deck. After printing CARD 00, the program lists the entire card deck which was submitted. This is strictly a listing of the cards; it is without regard to any illegal characters, input format errors, or program logic. This listing can be useful in locating input data errors that may be found in the following output groups.

6.3.2 User Messages (Figure 50)

The listing of the input data deck is followed by a set of messages notifying the user of any recent changes in the program or in the contents of ADB data sets. These messages are maintained by the ADB custodian and are only available if the ADB option has been installed with the program.

6.3.3 Input Data Printout

6.3.3.1 Problem Identification (Figure 51)

The value of the primary control variable, NPART, the problem identification number, IPSN, and the three cards of comments (CARDS 02, 03, and 04) appear at the beginning of each problem.

6.3.3.2 Basic Input Data Groups

All basic groups of input data except the elastic blade data blocks, airfoil data tables and the rotor-induced velocity distribution table are printed in the same sequence in which they

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS, EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS, EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS, EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS, EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS, EXT. 2886

PLEASE RETURN TO J.R. VAN GAASBEEK, ROTOR DYNAMICS, EXT. 2886

Figure 48. Message Card.

```
01
  C042201 AH-1G + OLS ROTOR SIMULATION       AGAP80 ARMY VERSION
 OLS COUNTER 615, FLIGHT 35A, 2900* HP, 27 DEG C   (PAN NAME C818TRMT)
 ELASTIC ROTOR, HSOFT = -17.0        OUTPUT TO GO INTO INPUT GUIDE
          OLS PROGRAM LOGIC GROUP
    0    2    0  -20    5    9    0    0    0    0    2    1    0    0
   -1   -1    1    1    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    1    5    1    2    0    1    0    0    0    1    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    1    1    1    1    0    8    0    0    0    0    0    0    0
    0    0    3    0    0    0    0    0    0    0    0    0    0    0
          MODEL 209 M/R AIRFOIL DATA TABLE
SUPER 540 EXT*DSUPER 540 EXT*D11391175 947
          0.0       0.3000 0.5000 0.6000 0.6500 0.7000 0.7500 0.8000 0.8500
          0.9000 1.0000
 -180.00  0.0       0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
          0.0       0.0
 -172.00 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800 0.7800
          0.7800 0.7800
 -161.00 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200 0.6200
          0.6200 0.6200
 -147.00 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000
          1.0000 1.0000
 -129.00 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000
          1.0000 1.0000
  -49.00-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800
         -1.1800-1.1800
  -39.00-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800-1.1800
         -1.1800-1.1800
  -21.00-0.8000-0.8100-0.8500-0.8500-0.8500-0.8500-0.7150-0.6800-0.6640
         -0.6400-0.6410
  -18.00-0.8580-0.8580-0.8820-0.8700-0.8700-0.8640-0.7540-0.7220-0.6980
         -0.6700-0.6680
  -14.00-1.1700-1.1700-0.9280-0.8710-0.6720-0.8530-0.8410-0.8010-0.7670
         -0.7280-0.7280
  -12.00-1.2200-1.2200-0.9350-0.8670-0.8670-0.8390-0.8400-0.8180-0.7780
         -0.7400-0.7370
  -11.00-1.1800-1.1800-0.9340-0.8620-0.8600-0.8290-0.8320-0.8120-0.7770
         -0.7400-0.7260
  -10.00-1.0700-1.0700-0.9300-0.8530-0.8540-0.8150-0.8200-0.8030-0.7700
         -0.7340-0.7050
   -9.00-0.9680-0.9680-0.9200-0.8380-0.8400-0.8050-0.8010-0.7810-0.7520
         -0.7180-0.6720
   -8.00-0.8600-0.8600-0.8900-0.8130-0.8190-0.7780-0.7800-0.7530-0.7300
         -0.6900-0.6320
   -7.00-0.7530-0.7530-0.8300-0.7840-0.7850-0.7540-0.7420-0.7200-0.7040
         -0.6520-0.5810
   -6.00-0.6450-0.6450-0.7100-0.7450-0.7220-0.7210-0.6790-0.6720-0.6680
         -0.6010-0.5200
   -4.00-0.4300-0.4300-0.4740-0.5240-0.5560-0.5890-0.5650-0.5600-0.5200
         -0.4500-0.3600
   -2.00-0.2150-0.2150-0.2370-0.2620-0.2780-0.2980-0.3120-0.3120-0.2600
         -0.2250-0.1800
    0.0   0.0       0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
          0.0       0.0
    2.00 0.2150 0.2150 0.2370 0.2620 0.2780 0.2980 0.3120 0.3120 0.2600
          0.2250 0.1800
    4.00 0.4300 0.4300 0.4740 0.5240 0.5560 0.5890 0.5650 0.5600 0.5200
          0.4500 0.3600
    6.00 0.6450 0.6450 0.7100 0.7450 0.7220 0.7210 0.6790 0.6720 0.6680
          0.6010 0.5200
    7.00 0.7530 0.7530 0.8300 0.7840 0.7850 0.7540 0.7420 0.7200 0.7040
          0.6520 0.5810
    8.00 0.8600 0.8600 0.8900 0.8130 0.8190 0.7780 0.7800 0.7530 0.7300
          0.6900 0.6320
    9.00 0.9680 0.9680 0.9200 0.8380 0.8400 0.8050 0.8010 0.7810 0.7520
          0.7180 0.6720
   10.00 1.0750 1.0750 0.9300 0.8530 0.8540 0.8150 0.8200 0.8030 0.7700
          0.7340 0.7050
   11.00 1.1840 1.1840 0.9340 0.8620 0.8600 0.8290 0.8320 0.8120 0.7770
          0.7400 0.7260
   12.00 1.2200 1.2200 0.9350 0.8670 0.8670 0.8390 0.8400 0.8180 0.7780
          0.7400 0.7370
   14.00 1.1720 1.1720 0.9280 0.8710 0.8720 0.8530 0.8410 0.8010 0.7670
          0.7280 0.7280
   18.00 0.8580 0.8580 0.8820 0.8700 0.8700 0.8640 0.7540 0.7220 0.6980
          0.6700 0.6680
   21.00 0.8000 0.8100 0.8500 0.8500 0.8500 0.8500 0.7150 0.6800 0.6640
          0.6400 0.6410
   39.00 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800
          1.1800 1.1800
   49.00 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800 1.1800
          1.1800 1.1800
  129.00-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000
         -1.0000-1.0000
```

Figure 49. Listing of Input Data Deck.

```
147.00-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000-1.0000   00008800
        -1.0000-1.0000                                                   00008900
161.00-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200   00009000
        -0.6200-0.6200                                                   00009100
172.50-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800-0.7800   00009200
        -0.7800-0.7800                                                   00009300
180.00 0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0      00009400
        0.0     0.0                                                      00009500
        0.0     0.3000 0.5000 0.6000 0.6500 0.7000 0.7500 0.8000 0.8500 00009600
        0.9000 1.0000                                                    00009700
-180.000.022000.022000.022000.022000.022000.022000.022000.022000.02200  00009800
        0.022000.02200                                                   00009900
-175.000.062000.062000.062000.062000.062000.062000.062000.062000.06200  00010000
        0.062000.06200                                                   00010100
-170.000.132000.132000.132000.132000.132000.132000.132000.132000.13200  00010200
        0.132000.13200                                                   00010300
-165.000.242000.242000.242000.242000.242000.242000.242000.242000.24200  00010400
        0.242000.24200                                                   00010500
-160.000.302000.302000.302000.302000.302000.302000.302000.302000.30200  00010600
        0.302000.30200                                                   00010700
-140.001.042001.042001.042001.042001.042001.042001.042001.042001.04200  00010800
        1.042001.04200                                                   00010900
-120.001.652001.652001.652001.652001.652001.652001.652001.652001.65200  00011000
        1.652001.65200                                                   00011100
-110.001.852001.852001.852001.852001.852001.852001.852001.852001.85200  00011200
        1.852001.85200                                                   00011300
-100.002.002002.002002.002002.002002.002002.002002.002002.002002.00200  00011400
        2.002002.00200                                                   00011500
 -90.002.022002.022002.022002.002002.002002.002002.002002.002002.00200  00011600
        2.002002.00200                                                   00011700
 -80.001.962001.962001.962001.962001.962001.962001.962001.962001.96200  00011800
        1.962001.96200                                                   00011900
 -70.001.842001.842001.842001.842001.842001.842001.842001.842001.84200  00012000
        1.842001.84200                                                   00012100
 -60.001.662001.662001.662001.662001.662001.662001.662001.662001.66200  00012200
        1.662001.66200                                                   00012300
 -50.001.392001.392001.392001.392001.392001.392001.392001.392001.39200  00012400
        1.392001.39200                                                   00012500
 -30.000.600000.600000.600000.600000.600000.600000.600000.600000.60000  00012600
        0.600000.60000                                                   00012700
 -28.000.540000.540000.563000.578000.578000.581000.581000.581000.58100  00012800
        0.581000.58100                                                   00012900
 -26.000.480000.480000.522000.545000.545000.547000.558000.558000.55800  00013000
        0.558000.55800                                                   00013100
 -24.000.420000.420000.469000.500000.502000.512000.526000.526000.52600  00013200
        0.526000.52600                                                   00013300
 -22.000.358000.358000.409000.448000.461000.472000.489000.491000.49100  00013400
        0.491000.49100                                                   00013500
 -20.000.299000.299000.351000.396000.414000.431000.451000.453000.45300  00013600
        0.453000.45300                                                   00013700
 -18.000.240000.240000.300000.345000.370000.386000.407000.414000.41900  00013800
        0.419000.41900                                                   00013900
 -16.000.191000.191000.253000.300000.326000.341000.358000.367000.38100  00014000
        0.389000.38900                                                   00014100
 -15.000.167000.167000.232000.275000.303000.318000.333000.342000.36500  00014200
        0.372000.37200                                                   00014300
 -13.500.135000.135000.202000.244000.271000.283000.299000.309000.33900  00014400
        0.350000.35100                                                   00014500
 -12.500.100500.100500.175000.220000.249000.261000.274000.285000.32100  00014600
        0.335000.33600                                                   00014700
 -11.500.046000.046000.142000.188000.226000.238000.251000.261000.30200  00014800
        0.319000.32100                                                   00014900
 -10.500.026000.026000.110000.158000.195000.212000.229000.240000.28700  00015000
        0.302000.30500                                                   00015100
  -9.500.017500.017500.078000.127000.164000.188000.204000.218000.26900  00015200
        0.287000.29100                                                   00015300
  -8.500.012500.012500.049000.096000.133000.162000.180000.195000.25000  00015400
        0.269000.27300                                                   00015500
  -7.500.010200.010200.027400.066000.102000.132000.155000.171000.23000  00015600
        0.250000.25700                                                   00015700
  -6.500.009200.009200.012400.039000.071000.102000.127000.146000.21000  00015800
        0.230000.23900                                                   00015900
  -5.500.008500.008500.010000.022300.041500.071500.098500.120000.18700  00016000
        0.211000.22000                                                   00016100
  -4.500.008000.008000.009200.013400.020000.043000.076000.100000.16600  00016200
        0.190000.19800                                                   00016300
  -3.500.007900.007900.008600.008900.012800.026000.045000.070000.14100  00016400
        0.166000.17600                                                   00016500
  -2.500.007400.007400.007800.007800.009300.016500.027000.042000.11000  00016600
        0.140000.15000                                                   00016700
  -1.500.007100.007100.007100.007000.007300.009800.016500.026500.07000  00016800
        0.105000.12000                                                   00016900
  -0.500.006800.006800.006800.006700.006500.007200.008900.016800.05000  00017000
        0.072000.09500                                                   00017100
   0.0  0.006800.006800.006700.006600.006500.006800.007400.015000.04500  00017200
        0.069000.09300                                                   00017300
   0.500.006800.006800.006800.006700.006500.007200.008900.016800.05000  00017400
        0.072000.09500                                                   00017500
```

Figure 49. Continued.

```
1.500.007100.007100.007100.007000.007300.009800.016500.026500.07000    00017600
      0.105000.12000                                                   00017700
2.500.007400.007400.007800.007800.009300.016500.027000.042000.11600    00017800
      0.140000.15000                                                   00017900
3.500.007900.007900.008600.008900.012800.026000.045000.076000.14100    00018000
      0.166000.17600                                                   00018100
4.500.008000.008000.009200.013400.020000.043000.070000.100000.16600    00018200
      0.190000.19800                                                   00018300
5.500.008500.008500.010000.022300.041500.071500.098500.120000.18700    00018400
      0.211000.22000                                                   00018500
6.500.009200.009200.012400.039000.071000.102000.127000.146000.21000    00018600
      0.230000.23900                                                   00018700
7.500.010200.010200.027400.066000.102000.132000.155000.171000.23000    00018800
      0.250000.25700                                                   00018900
8.500.012500.012500.049000.096000.133000.162000.180000.195000.25000    00019000
      0.269000.27300                                                   00019100
9.500.017500.017500.078000.127000.164000.188000.204000.218000.26900    00019200
      0.287000.29100                                                   00019300
10.500.026000.026000.110000.158000.195000.212000.229000.240000.28700   00019400
      0.302000.30500                                                   00019500
11.500.046000.046000.142000.188000.226000.238000.251000.261000.30200   00019600
      0.319000.32100                                                   00019700
12.500.100500.100500.175000.220000.249000.261000.274000.285000.32100   00019800
      0.335000.33600                                                   00019900
13.500.135000.135000.202000.244000.271000.283000.299000.309000.33900   00020000
      0.350000.35100                                                   00020100
15.000.167000.167000.232000.275000.303000.318000.333000.342000.36500   00020200
      0.372000.37200                                                   00020300
16.000.191000.191000.253000.300000.326000.341000.358000.367000.38100   00020400
      0.389000.38900                                                   00020500
18.000.240000.240000.300000.345000.370000.386000.407000.414000.41900   00020600
      0.419000.41900                                                   00020700
20.000.299000.299000.351000.396000.414000.431000.451000.453000.45300   00020800
      0.453000.45300                                                   00020900
22.000.358000.358000.409000.448000.461000.472000.489000.491000.49100   00021000
      0.491000.49100                                                   00021100
24.000.420000.420000.469000.500000.502000.512000.526000.526000.52600   00021200
      0.526000.52600                                                   00021300
26.000.480000.480000.522000.545000.545000.547000.558000.558000.55800   00021400
      0.558000.55800                                                   00021500
28.000.540000.540000.563000.578000.578000.581000.581000.581000.58100   00021600
      0.581000.58100                                                   00021700
30.000.600000.600000.600000.600000.600000.600000.600000.600000.60000   00021800
      0.600000.60000                                                   00021900
50.001.392001.392001.392001.392001.392001.392001.392001.392001.39200   00022000
      1.392001.39200                                                   00022100
60.001.662001.662001.662001.662001.662001.662001.662001.662001.66200   00022200
      1.662001.66200                                                   00022300
70.001.842001.842001.842001.842001.842001.842001.842001.842001.84200   00022400
      1.842001.84200                                                   00022500
80.001.962001.962001.962001.962001.962001.962001.962001.962001.96200   00022600
      1.962001.96200                                                   00022700
90.002.002002.002002.002002.002002.002002.002002.002002.002002.00200   00022800
      2.002002.00200                                                   00022900
100.002.002002.002002.002002.002002.002002.002002.002002.002002.00200  00023000
      2.002002.00200                                                   00023100
110.001.852001.852001.852001.852001.852001.852001.852001.852001.85200  00023200
      1.852001.85200                                                   00023300
120.001.652001.652001.652001.652001.652001.652001.652001.652001.65200  00023400
      1.652001.65200                                                   00023500
140.001.042001.042001.042001.042001.042001.042001.042001.042001.04200  00023600
      1.042001.04200                                                   00023700
160.000.302000.302000.302000.302000.302000.302000.302000.302000.30200  00023800
      0.302000.30200                                                   00023900
165.000.242000.242000.242000.242000.242000.242000.242000.242000.24200  00024000
      0.242000.24200                                                   00024100
170.000.132000.132000.132000.132000.132000.132000.132000.132000.13200  00024200
      0.132000.13200                                                   00024300
175.000.062000.062000.062000.062000.062000.062000.062000.062000.06200  00024400
      0.062000.06200                                                   00024500
180.000.022000.022000.022000.022000.022000.022000.022000.022000.02200  00024600
      0.022000.02200                                                   00024700
       0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.7500 0.8000 0.9000  00024800
-180.000.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0     00024900
-170.000.400000.400000.400000.400000.400000.400000.400000.400000.40000 00025000
-165.000.300000.300000.300000.300000.300000.300000.300000.300000.30000 00025100
-160.000.300000.300000.300000.300000.300000.300000.300000.300000.30000 00025200
-135.000.500000.500000.500000.500000.500000.500000.500000.500000.50000 00025300
-90.000.500000.500000.500000.500000.500000.500000.500000.500000.50000  00025400
-30.000.174000.184000.196000.214000.235000.25[illegible]000.264000.277000.29800  00025500
-25.000.112000.118000.128000.144000.157000.171000.183000.206000.23200  00025600
-16.000.073000.078000.086000.097000.108000.117000.137000.176000.20000  00025700
-15.000.054000.065000.073000.084000.097000.111000.133000.173000.19500  00025800
-14.000.0     0.027000.054000.068000.086000.103000.127000.167000.18900 00025900
-13.000.0     0.001500.025000.050000.074000.093000.122000.163000.18400 00026000
-12.000.0     0.0     0.002000.030000.066000.083000.116000.157000.17600 00026100
-11.000.0     0.0     -.003000.014000.046000.074000.108000.149000.17100 00026200
-10.000.0     0.0     -.002000.002000.032000.065000.100000.142000.16300 00026300
```

Figure 49. Continued.

```
-9.000.0         0.0       0.0       -.003000.016000.054000.089000.132000.15400      00026400
-8.000.0         0.0       0.0       -.004000.005000.041000.082000.123000.14500      00026500
-7.000.0         0.0       0.0       0.0       -.004000.027500.072000.112500.13600   00026600
-6.000.0         0.0       0.0       0.0       -.003000.016000.062000.100000.12500   00026700
-4.000.0         0.0       0.0       0.0       0.0       0.005000.045000.076000.10200 00026800
-3.000.0         0.0       0.0       0.0       0.0       -.003000.026000.066500.08700 00026900
-2.000.0         0.0       0.0       0.0       0.0       0.0       0.013000.053000.07000 00027000
-1.000.0         0.0       0.0       0.0       0.0       0.0       0.003500.033000.04500 00027100
0.000.0          0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0 00027200
1.000.0          0.0       0.0       0.0       0.0       0.0       -.00400-.03300-.04500 00027300
2.000.0          0.0       0.0       0.0       0.0       0.0       -.01300-.05300-.07000 00027400
3.000.0          0.0       0.0       0.0       0.0       0.00250-.02600-.06700-.08700   00027500
4.000.0          0.0       0.0       0.0       0.0       -.00500-.04000-.07600-.10200   00027600
6.000.0          0.0       0.0       0.0       0.00300-.01600-.06300-.10000-.12500     00027700
7.000.0          0.0       0.0       0.0       0.00400-.02800-.07200-.11300-.13600     00027800
8.000.0          0.0       0.0       0.00400-.00500-.04100-.08200-.12300-.14500       00027900
9.000.0          0.0       0.0       0.00300-.01600-.05400-.08900-.13200-.15400       00028000
10.000.0         0.0       0.00150-.00200-.03200-.06500-.10000-.14200-.16300         00028100
11.000.0         0.0       0.00300-.01400-.04600-.07400-.10800-.14900-.17000         00028200
12.000.0         0.0       -.00200-.03600-.06000-.08300-.11600-.15700-.17600         00028300
13.000.0         -.00200-.02500-.05000-.07400-.09300-.12200-.16300-.18400           00028400
14.000.0         -.02700-.05400-.06800-.08600-.10300-.12700-.16700-.18900           00028500
15.00-.05400-.06500-.07300-.08400-.09700-.11100-.13300-.17300-.19500                00028600
16.00-.07300-.07800-.08600-.09700-.10800-.11700-.13700-.17600-.20000                00028700
20.00-.11200-.11800-.12800-.14400-.15700-.17100-.18300-.20600-.23200                00028800
30.00-.17400-.18400-.19600-.21400-.23500-.25000-.26400-.27700-.29800                00028900
90.00-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000                00029000
135.00-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000-.50000               00029100
160.00-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000               00029200
165.00-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000-.30000               00029300
170.00-.40000-.40000-.40000-.40000-.40000-.40000-.40000-.40000-.40000               00029400
180.000.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0 00029500
           NACA 0015 AS PROVIDED BY PAI   (03-19-77)                                00029600
      NACA 0015                     7411281 2 2                                      00029700
         0.        .2        .4        .5        .6        .8        1.0             00029800
-180.0  0.0      0.0       0.0       0.0       0.0       0.0       0.0               00029900
-170.0  0.800000.800000.800000.800000.800000.800000.80000                            00030000
-160.0  0.620000.620000.620000.620000.620000.620000.62000                            00030100
-150.0  0.800000.800000.800000.800000.800000.800000.80000                            00030200
-130.0  0.800000.800000.800000.800000.800000.800000.80000                            00030300
-50.0   -0.9800-0.9800-0.9800-0.9800-0.9800-0.9800-0.9800                            00030400
-30.0   -0.8700-0.8700-0.8700-0.8700-0.8700-0.8700-0.8700                            00030500
-20.0   -0.9000-0.9000-0.9000-0.9000-0.9000-0.9000-0.9000                            00030600
-17.0   -1.4400-1.4400-1.2500-0.9750-0.8820-0.7800-0.5300                            00030700
-16.0   -1.4700-1.4700-1.2700-1.0000-0.8800-0.7400-0.4100                            00030800
-15.0   -1.4800-1.4800-1.2900-1.0300-0.8800-0.7000-0.2900                            00030900
-14.0   -1.4500-1.4500-1.3000-1.0900-0.9350-0.7400-0.2900                            00031000
-13.0   -1.3500-1.3500-1.2900-1.1400-0.9600-0.7500-0.2850                            00031100
-12.0   -1.2500-1.2500-1.2500-1.1500-0.9800-0.7100-0.2750                            00031200
-11.0   -1.1500-1.1500-1.1600-1.1500-1.0100-0.6800-0.2650                            00031300
-10.0   -1.0500-1.0500-1.0700-1.1000-1.0100-0.6450-0.2400                            00031400
-9.0    -0.9450-0.9450-0.9700-1.0400-1.0100-0.6100-0.2150                            00031500
-8.0    -0.8400-0.8400-0.8700-0.9200-0.9600-0.5550-0.1900                            00031600
-7.0    -0.7350-0.7350-0.7630-0.8150-0.9100-0.5000-0.1650                            00031700
-6.0    -0.6300-0.6300-0.6550-0.7100-0.7700-0.4300-0.1400                            00031800
0.0     0.0      0.0       0.0       0.0       0.0       0.0       0.0               00031900
6.0     0.630000.630000.655000.710000.770000.430000.14000                            00032000
7.0     0.735000.735000.763000.815000.910000.500000.16500                            00032100
8.0     0.840000.840000.870000.920000.960000.555000.19000                            00032200
9.0     0.945000.945000.970001.040001.010000.610000.21500                            00032300
10.0    1.050001.050001.070001.100001.010000.645000.24000                            00032400
11.0    1.150001.150001.160001.150001.010000.680000.26500                            00032500
12.0    1.250001.250001.250001.150000.980000.710000.27500                            00032600
13.0    1.350001.350001.290001.140000.960000.750000.28500                            00032700
14.0    1.450001.450001.300001.090000.935000.740000.29000                            00032800
15.0    1.480001.480001.290001.030000.880000.700000.29000                            00032900
16.0    1.470001.470001.270001.000000.880000.740000.41000                            00033000
17.0    1.440001.440001.250000.975000.882000.780000.53000                            00033100
20.0    0.900000.900000.900000.900000.900000.900000.90000                            00033200
30.0    0.870000.870000.870000.870000.870000.870000.87000                            00033300
50.0    0.980000.980000.980000.980000.980000.980000.98000                            00033400
130.0   -0.8000-0.8000-0.8000-0.8000-0.8000-0.8000-0.8000                            00033500
150.0   -0.8000-0.8000-0.8000-0.8000-0.8000-0.8000-0.8000                            00033600
160.0   -0.6200-0.6200-0.6200-0.6200-0.6200-0.6200-0.6200                            00033700
170.0   -0.8000-0.8000-0.8000-0.8000-0.8000-0.8000-0.8000                            00033800
180.0   0.0      0.0       0.0       0.0       0.0       0.0       0.0               00033900
        .0       .2        .3        .4        .5        .6        .7        .75       .8 00034000
        .85      .9        1.0                                                       00034100
-180.0  0.034300.034300.034300.034300.034300.034300.034300.036300.05560              00034200
        0.090000.126000.12600                                                        00034300
-179.0  0.034500.034500.034500.034500.034500.034500.035600.044300.07060              00034400
        0.108000.143000.14300                                                        00034500
-178.0  0.034800.034800.034800.034800.034800.034800.037700.053600.09060              00034600
        0.126000.160000.16000                                                        00034700
-177.0  0.035100.035100.035100.035100.035100.035100.041100.064100.10800              00034800
        0.143000.177000.17700                                                        00034900
-176.0  0.035600.035600.035600.035600.035600.036000.048600.074600.12600              00035000
        0.161000.193000.19300                                                        00035100
```

Figure 49. Continued.

```
-175.0 0.036500.036500.036500.036500.036500.038000.061800.095600.14600   00035200
       0.179000.210000.21000                                              00035300
-174.0 0.037600.037600.037600.037600.037700.041300.082600.117000.16400   00035400
       0.196000.226000.22600                                              00035500
-173.0 0.038800.038800.038800.038800.040000.049700.106000.138000.18300   00035600
       0.214000.243000.24300                                              00035700
-172.0 0.040100.040100.040100.040100.042800.065600.128000.159000.20200   00035800
       0.232000.260000.26000                                              00035900
-171.0 0.041600.041600.041600.041900.049600.091600.151000.179000.22100   00036000
       0.249000.276000.27600                                              00036100
-170.0 0.043600.043600.043600.049800.075600.118000.173000.200000.24000   00036200
       0.267000.293000.29300                                              00036300
-169.0 0.048100.048800.049600.064600.104000.143000.195000.221000.25800   00036400
       0.285000.310000.31000                                              00036500
-168.0 0.053100.053800.056100.083100.133000.170000.216000.241000.27700   00036600
       0.303000.326000.32600                                              00036700
-167.0 0.059600.060800.064800.105000.161000.194000.239000.262000.29600   00036800
       0.321000.343000.34300                                              00036900
-166.0 0.080600.087400.098100.133000.190000.220000.261000.283000.31400   00037000
       0.338000.360000.36000                                              00037100
-165.0 0.115000.120000.132000.166000.219000.245000.283000.304000.33300   00037200
       0.356000.376000.37600                                              00037300
-164.0 0.146000.158000.169000.201000.246000.271000.306000.325000.35200   00037400
       0.374000.393000.39300                                              00037500
-160.0 0.320000.330000.336000.348000.360000.373000.394000.406000.42600   00037600
       0.442000.458000.45800                                              00037700
-130.0 1.250001.250001.250001.250001.250001.250001.250001.250001.25000   00037800
       1.250001.250001.25000                                              00037900
-90.0  1.770001.770001.770001.770001.770001.770001.770001.770001.77000   00038000
       1.770001.770001.77000                                              00038100
-50.0  1.150001.150001.150001.150001.150001.150001.150001.150001.15000   00038200
       1.150001.150001.15000                                              00038300
-20.0  0.300000.304000.310000.322000.334000.347000.368000.380000.40000   00038400
       0.416000.432000.43200                                              00038500
-18.0  0.126000.138000.149000.180000.259000.279000.309000.326000.35100   00038600
       0.382000.400000.40000                                              00038700
-17.0  0.095100.100000.112000.145000.222000.246000.280000.299000.32600   00038800
       0.365000.383000.38300                                              00038900
-16.0  0.060600.067400.078100.112000.195000.220000.257000.278000.30700   00039000
       0.348000.367000.36700                                              00039100
-15.0  0.049700.051300.056600.084000.166000.195000.235000.257000.28800   00039200
       0.330000.350000.35000                                              00039300
-14.0  0.041300.042200.045300.062000.137000.169000.213000.236000.27000   00039400
       0.312000.334000.33400                                              00039500
-13.0  0.034900.035800.036800.043500.109000.145000.190000.215000.25100   00039600
       0.295000.317000.31700                                              00039700
-12.0  0.029000.029000.029000.036000.079200.118000.169000.195000.23200   00039800
       0.277000.300000.30000                                              00039900
-11.0  0.026000.026300.026000.026300.051600.092700.147000.174000.21500   00040000
       0.259000.284000.28400                                              00040100
-10.0  0.023400.023400.023400.023400.032800.066700.125000.153000.19500   00040200
       0.241000.267000.26700                                              00040300
-9.0   0.020800.020800.020800.020800.024000.040700.102000.133000.17600   00040400
       0.223000.250000.25000                                              00040500
-8.0   0.018900.018900.018900.018900.020000.032000.080200.112000.15700   00040600
       0.206000.234000.23400                                              00040700
-7.0   0.017200.017200.017200.017200.017200.021100.052200.091000.13600   00040800
       0.188000.217000.21700                                              00040900
-6.0   0.015600.015600.015600.015600.015600.016900.036400.070000.12000   00041000
       0.170000.200000.20000                                              00041100
-5.0   0.014100.014100.014100.014100.014100.014100.030100.049000.10000   00041200
       0.153000.184000.18400                                              00041300
-4.0   0.013000.013000.013000.013000.013000.013000.020400.042700.08250   00041400
       0.135000.167000.16700                                              00041500
-3.0   0.012300.012300.012300.012300.012300.012300.015900.036400.06500   00041600
       0.117000.151000.15100                                              00041700
-2.0   0.012000.012000.012000.012000.012000.012000.013200.024300.04500   00041800
       [illegible].134000.13400                                           00041900
-1.0   0.011500.011500.011500.011500.011500.011500.011500.015000.03900   00042000
       0.082500.117000.11700                                              00042100
0.0    0.011300.011300.011300.011300.011300.011300.011300.012500.03300   00042200
       0.065000.100000.10000                                              00042300
1.0    0.011500.011500.011500.011500.011500.011500.011500.015000.03900   00042400
       0.082500.117000.11700                                              00042500
2.0    0.012000.012000.012000.012000.012000.012000.013200.024300.04500   00042600
       [illegible].134000.13400                                           00042700
3.0    0.012300.012300.012300.012300.012300.012300.015900.036400.06500   00042800
       0.117000.151000.15100                                              00042900
4.0    0.013000.013000.013000.013000.013000.013000.020400.042700.08250   00043000
       0.135000.167000.16700                                              00043100
5.0    0.014100.014100.014100.014100.014100.014100.030100.049000.10000   00043200
       0.153000.184000.18400                                              00043300
6.0    0.015600.015600.015600.015600.015600.016900.036400.070000.12000   00043400
       0.170000.200000.20000                                              00043500
7.0    0.017200.017200.017200.017200.017200.021100.052200.091000.13800   00043600
       0.188000.217000.21700                                              00043700
8.0    0.018900.018900.018900.018900.020000.032000.080200.112000.15700   00043800
       0.206000.234000.23400                                              00043900
```

Figure 49. Continued.

```
9.0       0.020800.020800.020800.020800.024000.040700.102000.133000.17600   00044000
          0.223000.250000.25000                                             00044100
10.0      0.023400.023400.023400.023400.032800.066700.125000.153000.19500   00044200
          0.241000.267000.26700                                             00044300
11.0      0.026000.026000.026000.026300.051600.092700.147000.174000.21500   00044400
          0.259000.284000.28400                                             00044500
12.0      0.029000.029000.029000.036000.079200.118000.169000.195000.23200   00044600
          0.277000.300000.30000                                             00044700
13.0      0.034900.035800.036800.043500.109000.145000.190000.215000.25100   00044800
          0.295000.317000.31700                                             00044900
14.0      0.041300.042200.045300.062000.137000.169000.213000.236000.27000   00045000
          0.312000.334000.33400                                             00045100
15.0      0.049700.051300.056600.084000.166000.195000.235000.257000.28800   00045200
          0.330000.350000.35000                                             00045300
16.0      0.066000.067400.078100.112000.195000.220000.257000.278000.30700   00045400
          0.348000.367000.36700                                             00045500
17.0      0.095100.100000.112000.145000.222000.246000.280000.299000.32600   00045600
          0.365000.383000.38300                                             00045700
18.0      0.126000.138000.149000.180000.259000.279000.309000.326000.35100   00045800
          0.382000.400000.40000                                             00045900
20.0      0.300000.304000.310000.322000.334000.347000.368000.380000.40000   00046000
          0.416000.432000.43200                                             00046100
50.0      1.150001.150001.150001.150001.150001.150001.150001.150001.15000   00046200
          1.150001.150001.15000                                             00046300
90.0      1.770001.770001.770001.770001.770001.770001.770001.770001.77000   00046400
          1.770001.770001.77000                                             00046500
130.0     1.250001.250001.250001.250001.250001.250001.250001.250001.25000   00046600
          1.250001.250001.25000                                             00046700
160.0     0.326000.330000.336000.348000.360000.373000.394000.406000.42600   00046800
          0.442000.458000.45800                                             00046900
164.0     0.146000.158000.169000.201000.246000.271000.306000.325000.35200   00047000
          0.374000.393000.39300                                             00047100
165.0     0.114000.120000.132000.166000.219000.245000.283000.304000.33300   00047200
          0.356000.376000.37600                                             00047300
166.0     0.086600.087400.098100.133000.190000.220000.261000.283000.31400   00047400
          0.338000.360000.36000                                             00047500
167.0     0.059600.060800.064800.105000.161000.194000.239000.262000.29600   00047600
          0.321000.343000.34300                                             00047700
168.0     0.053100.053800.056100.083100.133000.170000.216000.241000.27700   00047800
          0.303000.326000.32600                                             00047900
169.0     0.048100.048800.049600.064600.104000.143000.195000.221000.25800   00048000
          0.285000.310000.31000                                             00048100
170.0     0.043600.043600.043600.049800.075600.118000.173000.200000.24000   00048200
          0.267000.293000.29300                                             00048300
171.0     0.041600.041600.041600.041900.049600.091600.151000.179000.22100   00048400
          0.249000.276000.27600                                             00048500
172.0     0.040100.040100.040100.040100.042800.065600.128000.159000.20200   00048600
          0.232000.260000.26000                                             00048700
173.0     0.038800.038800.038800.038800.040000.049700.106000.138000.18300   00048800
          0.214000.243000.24300                                             00048900
174.0     0.037600.037600.037600.037600.037700.041300.082600.117000.16400   00049000
          0.196000.226000.22600                                             00049100
175.0     0.036500.036500.036500.036500.036500.038000.061800.095600.14600   00049200
          0.179000.210000.21000                                             00049300
176.0     0.035600.035600.035600.035600.035600.036000.048600.074600.12600   00049400
          0.161000.193000.19300                                             00049500
177.0     0.035100.035100.035100.035100.035100.035100.041100.064100.10800   00049600
          0.143000.177000.17700                                             00049700
178.0     0.034800.034800.034800.034800.034800.034800.037700.053600.09060   00049800
          0.126000.160000.16000                                             00049900
179.0     0.034500.034500.034500.034500.034500.034500.035600.044300.07060   00050000
          0.108000.143000.14300                                             00050100
180.0     0.034300.034300.034300.034300.034300.034300.034300.036300.05560   00050200
          0.090600.126000.12600                                             00050300
          0.0     1.0                                                       00050400
-180.0                                                                      00050500
 180.0                                                                      00050600
          AH-1G MAIN ROTOR GROUP 209 ROTOR WITH OLS INSTR.                  00050700
2.0       4.50      101.0     22.0      0.0       -10.0     12.0            00050800
200.0     0.0       152.76    475.6     1385.08   .0491     0.0             00050900
1.0       0.0       18099.    0.0       1.0       0.0       3.4             00051000
2.75      0.0       0.0       .13       0.0       0.0       0.0             00051100
0.0       0.0       -9.067    14.1      0.0       0.0       -0.682          00051200
0.0       0.0       0.0       0.0       2.0       -0.759    100.55          00051300
0.0       0.0       0.0       0.0       0.0       0.0       0.0             00051400
5.4       0.0       0.0       0.0       0.0       0.0       0.0             00051500
6.0       20.575    37.5      52.8      66.0      81.5      92.4            00051600
103.0     118.8     132.0     145.2     155.8     171.6     184.8           00051700
198.0     212.3     224.4     238.1     250.8     264.0                     00051800
0.0       0.0       0.0       0.0       0.0       0.0       -0.28125        00051900
-0.28125  -0.28125  -0.28125  -0.28125  -0.28125  -0.28125  -0.28125        00052000
-0.28125  -0.28125  -0.28125  -0.28125  -0.28125  -0.28125  0.0             00052100
14.0      19.6      8.2       27.0      27.0      27.0      28.625          00052200
28.625    28.625    28.625    28.625    28.625    28.625    28.625          00052300
28.625    28.625    28.625    28.625    28.625    28.625                    00052400
          540279  26 SEG OLS MR  PRECONE AND UNDERSLING HSOFT = -17.2       00052500
    5.3702    5.7138    6.1672    4.8217    0.9520    0.7750    0.8580      00052600
    0.8360    0.8690    0.7620    0.7260    0.8750    1.0980    1.0620      00052700
```

Figure 49. Continued.

```
    1.0390    1.2600    1.1860    1.2660    1.1890    1.1600    0.0       00052800
0.000100000.059028130.089800000.013079740.002400000.001700000.00170000  00052900
0.001700000.001800000.001400000.001300000.001400000.002400000.00240000  00053000
0.001400000.001200000.001300000.001500000.001800000.002700000.0         00053100
0.069000000.114854890.118969870.226381700.118300000.118900000.14690000  00053200
0.145300000.155300000.135700000.130500000.128000000.146000000.12900000  00053300
0.115900000.125500000.104500000.122600000.116100000.139900000.0         00053400
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       00053500
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       00053600
    0.0       0.0       0.0       0.0       0.0       0.0       0.0       00053700
    0.0       0.0533    3.6100    1.5292    0.9000    1.3900    1.7700    00053800
    1.7100    2.3850    1.4500    1.3400    0.8500    0.5708   -0.5500    00053900
    0.0100   -1.0170   -1.8700   -1.1290   -1.9700   -0.4300    0.0       00054000
       -1.  1.000027  3.162101     0.000     -4.78   5783.71         1 -100054100
     22.34  0.0         324.00     15.00  2.612248 -0.000515         1 -100054200
   68.2346    5.0431   -0.0661   -0.0025  0.053497  0.000179         1 -100054300
 -0.000001  0.000181  -0.11166    0.0000  -84.5548   16.4946  1 -1      00054400
  0.022734  0.000161  -0.09915   10.7704  -81.9709  -18.4911  1 -1      00054500
  0.078096  0.000172  -0.04525   10.6955  -75.9978 -120.2014  1 -1      00054600
  0.142384  0.000141  -0.10118   18.6203  -69.9713  -78.4327  1 -1      00054700
  0.200446  0.000082  -0.13356   35.0195  -63.7284  -35.6390  1 -1      00054800
  0.250541  0.000029  -0.16444   48.6442  -57.0024  -14.3409  1 -1      00054900
  0.309331 -0.000041  -0.20535   62.6420  -50.3783   -7.8601  1 -1      00055000
  0.350624 -0.000099  -0.23791   70.8787  -45.5232    8.2013  1 -1      00055100
  0.390743 -0.000160  -0.27199   76.1566  -41.3468   27.2729  1 -1      00055200
  0.450479 -0.000257  -0.32259   78.4713  -35.9540   63.0444  1 -1      00055300
  0.500340 -0.000344  -0.36833   77.6669  -31.8884  104.7575  1 -1      00055400
  0.550166 -0.000436  -0.41214   72.2795  -28.4886  137.3630  1 -1      00055500
  0.590156 -0.000515  -0.44544   66.2597  -26.1889  165.3552  1 -1      00055600
  0.649793 -0.000631  -0.48431   57.4585  -23.1217  199.1138  1 -1      00055700
  0.699654 -0.000727  -0.51026   51.2416  -20.0790  216.7308  1 -1      00055800
  0.749566 -0.000819  -0.52917   46.9985  -17.0037  223.8854  1 -1      00055900
  0.803685 -0.000917  -0.54184   43.3100  -13.5433  218.5189  1 -1      00056000
  0.849522 -0.000996  -0.54781   33.4993   -9.9614  174.3218  1 -1      00056100
  0.901486 -0.001060  -0.55040   23.9515   -6.3769  123.1197  1 -1      00056200
  0.949750 -0.001149  -0.55078   12.4606   -3.0319   60.3629  1 -1      00056300
  1.000000 -0.001212  -0.55071    2.3620   -0.5999    9.7422  1 -1      00056400
                                                              15 324. 1-00056500
       -1.  1.599443  2.510698     0.020   5251.70  -1296.81         2 -100056600
  -1342.10  0..         324.00     15.00 -2.723861  0.235062         2 -100056700
    0.0825   -0.8280   48.7245    1.3001 -0.044664 -0.196211         2 -100056800
  0.000000 -0.196724   0.00091        0.   118480.        3.  2 -1      00056900
 -0.015490 -0.199288  -0.00595    -1331.   115642.       26.  2 -1      00057000
 -0.068209 -0.192127   2.75899    -4255.   107964.     1127.  2 -1      00057100
 -0.113171 -0.165167   3.04416    -7167.    97854.      721.  2 -1      00057200
 -0.140030 -0.119578   3.17903    -9922.    88256.      534.  2 -1      00057300
 -0.164771 -0.073866   3.26606   -11555.    79730.      455.  2 -1      00057400
 -0.168256 -0.011751   3.35636   -11833.    70298.      428.  2 -1      00057500
 -0.161672  0.036395   3.41793   -11297.    63969.      390.  2 -1      00057600
 -0.150265  0.096024   3.46774   -10433.    58603.      358.  2 -1      00057700
 -0.127438  0.164085   3.51943    -8883.    49397.      319.  2 -1      00057800
 -0.104608  0.232488   3.54963    -7566.    42478.      288.  2 -1      00057900
 -0.079476  0.303352   3.56914    -6110.    35829.      273.  2 -1      00058000
 -0.057949  0.381824   3.57854    -5038.    30703.      263.  2 -1      00058100
 -0.024088  0.451099   3.58243    -3626.    23497.      258.  2 -1      00058200
  0.003891  0.527312   3.58168    -2643.    17972.      248.  2 -1      00058300
  0.032433  0.604731   3.57976    -1835.    12967.      238.  2 -1      00058400
  0.064471  0.669616   3.58036    -1160.     8270.      220.  2 -1      00058500
  0.091373  0.761960   3.58214     -698.     5019.      179.  2 -1      00058600
  0.121690  0.844252   3.58437     -343.     2239.      131.  2 -1      00058700
  0.149359  0.922621   3.58205 -125.1167  630.3089   70.5592  2 -1      00058800
  0.177566  1.000000   3.58116  -15.8482   14.2813   16.3724  2 -1      00058900
                                                              15 324. 2-00059000
       -1.  2.357852 13.776395     0.040  -5591.61  17334.48         3 -100059100
 -44839.62  0.0         324.00     15.00 -7.102327 -0.370118         3 -100059200
   -1.2801   -2.5932  -30.6560   -0.2790 -0.058877  0.207827         3 -100059300
  0.000000  0.211587   0.00438       -0.  -175567.      207.  3 -1      00059400
 -0.001116  0.210947   0.02700    -8809.  -172326.      207.  3 -1      00059500
 -0.126842  0.201986  70.52215    30877.  -162611.    34301.  3 -1      00059600
 -0.300501  0.166938  79.72098    35776.  -149901.    29179.  3 -1      00059700
 -0.453086  0.107524  83.20216    29450.  -138456.    26511.  3 -1      00059800
 -0.567151  0.052699  86.18941    22025.  -127607.    24384.  3 -1      00059900
 -0.671766 -0.012673  89.62363    14900.  -114613.    23390.  3 -1      00060000
 -0.717203 -0.057063  92.48225    10669.  -105400.    21940.  3 -1      00060100
 -0.734011 -0.097726  95.11710     7740.   -96290.    20560.  3 -1      00060200
 -0.716002 -0.155169  98.83375     4367.   -82737.    18686.  3 -1      00060300
 -0.663156 -0.200104 102.09225     2131.   -71591.    16677.  3 -1      00060400
 -0.575178 -0.242496 105.23556     1250.   -60564.    15111.  3 -1      00060500
 -0.478763 -0.274489 107.68665     1150.   -51912.    13748.  3 -1      00060600
 -0.308192 -0.321134 110.81715      644.   -39763.    12171.  3 -1      00060700
 -0.146534 -0.359715 113.12753     -246.   -30483.    10456.  3 -1      00060800
  0.020124 -0.398618 115.13460    -1582.   -22145.     9079.  3 -1      00060900
  0.222020 -0.441106 116.92508    -3376.   -14390.     7621.  3 -1      00061000
  0.392122 -0.477486 118.16934    -3335.    -8856.     6109.  3 -1      00061100
  0.578391 -0.519821 119.22220    -3269.    -4136.     4550.  3 -1      00061200
  0.734178 -0.561017 119.79440    -2071.    -1284.     2769.  3 -1      00061300
  0.880010 -0.605455 120.00000 -444.5662  -73.8982  922.0508  3 -1      00061400
                                                              15 324. 3-00061500
```

Figure 49. Continued.

-1.	2.856066	2.216849	0.023	-1108.53	-24899.88	4	-100061600
7626.20	0.0	324.00	15.00	-3.579679	-0.107229	4	-100061700
0.4818	-2.1624	-6.8485	-0.1947	-0.116089	0.040737	4	-100061800
-0.000000	0.041947	-0.01147	0.	-57826.	-113.	4 -1	00061900
-0.061025	0.041737	-0.05314	4550.	-57153.	-18.	4 -1	00062000
-0.150378	0.038895	-14.04663	9059.	-55043.	-5566.	4 -1	00062100
-0.241351	0.027291	-15.58658	16924.	-51193.	-5580.	4 -1	00062200
-0.321459	0.006743	-16.29219	18850.	-47080.	-5667.	4 -1	00062300
-0.384093	-0.011743	-16.90146	17879.	-43320.	-5411.	4 -1	00062400
-0.441570	-0.032465	-17.65942	16792.	-38797.	-5236.	4 -1	00062500
-0.472057	-0.046265	-18.23680	16134.	-35554.	-5027.	4 -1	00062600
-0.493048	-0.059041	-18.83677	15389.	-32395.	-4844.	4 -1	00062700
-0.505989	-0.076187	-19.75754	14210.	-27680.	-4646.	4 -1	00062800
-0.498199	-0.088491	-20.65234	13261.	-23770.	-4398.	4 -1	00062900
-0.469772	-0.098358	-21.59326	12495.	-19916.	-4108.	4 -1	00063000
-0.430084	-0.104232	-22.38507	12081.	-16877.	-3806.	4 -1	00063100
-0.337325	-0.108821	-23.47308	11367.	-12587.	-3368.	4 -1	00063200
-0.226846	-0.108606	-24.32776	10587.	-9330.	-2762.	4 -1	00063300
-0.084327	-0.104588	-25.10132	9665.	-6417.	-2213.	4 -1	00063400
0.105232	-0.096228	-25.80655	8324.	-3780.	-1623.	4 -1	00063500
0.290153	-0.086408	-26.28386	6402.	-2104.	-1123.	4 -1	00063600
0.521666	-0.073202	-26.68456	3896.	-804.	-742.	4 -1	00063700
0.752180	-0.058998	-26.96014	1566.	-167.	-482.	4 -1	00063800
1.000000	-0.043676	-27.07975	105.4115	6.4924	-229.8067	4 -1	00063900
						15 324. 4	-00064000
-1.	4.502123	2.691704	0.021	624.58	47758.83	5	-100064100
5657.36	0.0	324.00	15.00	6.492745	0.164532	5	-100064200
-1.2342	2.1936	3.7770	0.0095	0.216222	-0.021749	5	-100064300
-0.000000	-0.023634	-0.00081	0.	69348.	175.	5 -1	00064400
0.115838	-0.023304	0.07330	-8930.	68887.	-4.	5 -1	00064500
0.275498	-0.019508	-1.92482	-49701.	87177.	-4538.	5 -1	00064600
0.398518	-0.012215	-2.26706	-74151.	83913.	2364.	5 -1	00064700
0.475626	0.004518	-1.69418	-66384.	81304.	5667.	5 -1	00064800
0.489870	0.018518	-0.96472	-50961.	78374.	6954.	5 -1	00064900
0.410933	0.013431	0.12927	-36891.	73469.	7317.	5 -1	00065000
0.304066	0.001564	1.06417	-29167.	69289.	7714.	5 -1	00065100
0.170332	-0.014054	2.14283	-22539.	64859.	7933.	5 -1	00065200
-0.062345	-0.040505	3.95150	-13304.	57874.	7987.	5 -1	00065300
-0.265170	-0.061323	5.71914	-6210.	51810.	7555.	5 -1	00065400
-0.452666	-0.077058	7.50551	640.	45758.	6943.	5 -1	00065500
-0.570081	-0.083442	8.89113	6571.	40957.	6235.	5 -1	00065600
-0.689592	-0.079416	10.60377	14180.	33773.	5346.	5 -1	00065700
-0.698268	-0.061149	11.77159	18470.	27684.	4593.	5 -1	00065800
-0.612644	-0.028065	12.69168	20770.	21642.	4151.	5 -1	00065900
-0.405939	0.024135	13.42686	19836.	15191.	3844.	5 -1	00066000
-0.147121	0.079432	13.95735	16276.	10065.	3732.	5 -1	00066100
0.215975	0.150571	14.40300	9609.	4986.	3258.	5 -1	00066200
0.592666	0.221053	14.47096	3388.	1590.	2142.	5 -1	00066300
1.000000	0.295952	14.42519	-46.5423	58.7771	644.6338	5 -1	00066400
						15 324. 5	-00066500
1.	1.043365	2.891906	0.020	-16.16	5806.66	1	100066600
12.10	0.0	324.00	15.00	2.319131	-0.055155	1	100066700
65.7206	4.6028	0.0002	-0.0176	0.023977	-0.001165	1	100066800
-0.000000	-0.000000	-0.03270	6702.	0.	-23.	1 1	00066900
0.021811	-0.000497	-0.03437	4630.	-55.	-26.	1 1	00067000
0.046088	-0.001025	-1.77708	2564.	-181.	-100.	1 1	00067100
0.106314	-0.002384	-1.82730	1925.	-239.	-70.	1 1	00067200
0.161318	-0.002920	-1.85368	1416.	-279.	-34.	1 1	00067300
0.210117	-0.003157	-1.88178	1059.3573	-297.1123	-14.3201	1 1	00067400
0.269232	-0.003056	-1.92024	863.0429	-285.9786	-7.7337	1 1	00067500
0.311330	-0.002839	-1.95104	699.6148	-263.2272	8.4066	1 1	00067600
0.352909	-0.002583	-1.98388	620.2547	-238.3863	27.8015	1 1	00067700
0.414896	-0.002143	-2.03305	526.3818	-199.3198	64.2759	1 1	00067800
0.466038	-0.001754	-2.07859	463.8959	-166.5974	107.3822	1 1	00067900
0.518895	-0.001351	-2.12280	398.6606	-136.9455	141.5464	1 1	00068000
0.560745	-0.001025	-2.15705	348.5411	-114.9885	171.1462	1 1	00068100
0.623442	-0.000501	-2.19816	285.8353	-85.0319	207.1550	1 1	00068200
0.676167	-0.000022	-2.22634	245.3763	-62.2178	226.7831	1 1	00068300
0.729266	0.000561	-2.24742	217.0266	-41.6348	235.3266	1 1	00068400
0.787177	0.001111	-2.26188	192.9669	-22.8594	230.6481	1 1	00068500
0.836458	0.001656	-2.26906	146.9324	-12.4069	184.5402	1 1	00068600
0.892604	0.002310	-2.27262	101.6482	-4.1641	130.6349	1 1	00068700
0.945082	0.002960	-2.27315	50.9713	-0.5283	63.9925	1 1	00068800
1.000000	0.003671	-2.27313	8.8254	0.0916	10.1272	1 1	00068900
						15 324. 1	00069000
1.	2.270090	10.993640	0.038	-8110.69	8632.22	2	100069100
-37321.28	0.0	324.00	15.00	-9.847487	-1.936770	2	100069200
-2.6732	-3.3422	0.7765	-0.7426	-0.090464	-0.039431	2	100069300
-0.000003	-0.000001	-0.13737	-8787.	-0.	240.	2 1	00069400
-0.004718	-0.016777	-0.11629	-13704.	1913.	248.	2 1	00069500
-0.181664	-0.057286	61.63460	17066.	6310.	28746.	2 1	00069600
-0.402432	-0.099356	69.28320	18879.	8575.	23847.	2 1	00069700
-0.581014	-0.132077	72.16347	10624.	7423.	21324.	2 1	00069800
-0.709190	-0.154331	74.59741	2413.	5912.	19488.	2 1	00069900
-0.816815	-0.169603	77.53023	-3799.	4790.	18657.	2 1	00070000
-0.845794	-0.172568	79.66004	-6554.	4278.	17445.	2 1	00070100
-0.849427	-0.169246	81.74937	-7805.	4007.	16298.	2 1	00070200
-0.809980	-0.155488	84.65669	-8489.	3700.	14744.	2 1	00070300

Figure 49. Continued.

```
-0.737610 -0.136551  87.17257    -8445.      3454.     13106.  2  1        00070400
-0.631910 -0.111615  89.57640    -7236.      3329.     11860.  2  1        00070500
-0.522563 -0.087371  91.43720    -5790.      3251.     10792.  2  1        00070600
-0.333192 -0.046609  93.79819    -4169.      2926.      9576.  2  1        00070700
-0.155695 -0.009793  95.53215    -3508.      2474.      8268.  2  1        00070800
 0.033694  0.029115  97.03564    -3435.      1888.      7224.  2  1        00070900
 0.249470  0.072859  98.37677    -3947.      1156.      6112.  2  1        00071000
 0.436683  0.110585  99.31294    -3331.       687.      4919.  2  1        00071100
 0.645454  0.153657 100.10684    -2898.       209.      3669.  2  1        00071200
 0.825798  0.191148 100.52903    -1754.       -16.      2218.  2  1        00071300
 1.000000  0.229485 100.67863 -376.3695   -31.1289  722.9441  2  1        00071400
                                                              15 324. 2 00071500
       1.  3.010958  2.269843     0.027   -3691.16 -26826.65          3 100071600
 11887.78  0.0         324.00     15.60 -3.696072 -0.700754          3 100071700
  -1.4912  -1.7705    -0.1466   -0.3628 -0.044422 -0.014444          3 100071800
 0.000000  0.000001   0.00001   -21027.       -0.         9.  3  1        00071900
-0.004592 -0.006153  -0.00296    -8200.       760.        17.  3  1        00072000
-0.079958 -0.021178 -14.63207    -5885.      2422.     -8607.  3  1        00072100
-0.176369 -0.039199 -17.01863     2139.      4206.     -8273.  3  1        00072200
-0.265272 -0.055295 -18.64343     5893.      4657.     -8137.  3  1        00072300
-0.337283 -0.067544 -18.92786     6777.      4679.     -7732.  3  1        00072400
-0.409169 -0.079150 -20.02564     7663.      4686.     -7487.  3  1        00072500
-0.450864 -0.085362 -20.65925     8272.      4693.     -7161.  3  1        00072600
-0.484249 -0.089657 -21.71948     8659.      4657.     -6909.  3  1        00072700
-0.515888 -0.092525 -23.02481     9034.      4551.     -6598.  3  1        00072800
-0.523758 -0.091255 -24.27495     9273.      4426.     -6225.  3  1        00072900
-0.509930 -0.086001 -25.57602     9598.      4268.     -5820.  3  1        00073000
-0.480570 -0.078598 -26.66127    10006.      4175.     -5407.  3  1        00073100
-0.399276 -0.061459 -28.14129    10396.      3897.     -4822.  3  1        00073200
-0.293807 -0.041366 -29.29851    10326.      3529.     -4016.  3  1        00073300
-0.151287 -0.015969 -30.34402    10069.      3069.     -3287.  3  1        00073400
 0.043950  0.017636 -31.29839     9054.      2440.     -2493.  3  1        00073500
 0.238572  0.048639 -31.94704     7172.      1766.     -1782.  3  1        00073600
 0.465058  0.087434 -32.49322     4487.       987.     -1209.  3  1        00073700
 0.732714  0.125432 -32.86310     1845.       365.      -766.  3  1        00073800
 1.000000  0.165890 -33.02163  126.5091    25.5156 -334.5708  3  1        00073900
                                                              15 324. 3 00074000
       1.  4.684472  2.807663     0.020   26934.63  51157.01          4 100074100
   -71.12  0.0         324.00     15.00  8.689367  2.981796          4 100074200
  -0.6479   1.6164    -0.2815    0.9836  0.100298  0.061562          4 100074300
 0.000000  0.000000   0.00002    42432.         0.      -113.  4  1        00074400
 0.019644  0.026236  -0.00153    18685.    -10114.      -129.  4  1        00074500
 0.180386  0.068899  -5.68682   -20265.    -33017.      -101.  4  1        00074600
 0.360206  0.149494  -4.70474   -47205.    -51037.      7382.  4  1        00074700
 0.492479  0.189459  -3.43346   -41747.    -54657.     11288.  4  1        00074800
 0.547669  0.206499  -2.01639   -27565.    -53023.     13007.  4  1        00074900
 0.561651  0.203960   0.01154   -15615.    -51181.     13519.  4  1        00075000
 0.407994  0.185943   1.71542    -9552.    -49749.     14098.  4  1        00075100
 0.278666  0.159377   3.64021    -4573.    -47962.     14443.  4  1        00075200
 0.040102  0.106307   6.62427     2344.    -44289.     14612.  4  1        00075300
-0.177325  0.060032   9.95922     7583.    -40388.     14112.  4  1        00075400
-0.385631  0.011325  13.16726    12857.    -35866.     13274.  4  1        00075500
-0.527522 -0.024933  15.76569    17228.    -31660.     12241.  4  1        00075600
-0.669267 -0.070083  19.08319    23023.    -24838.     10852.  4  1        00075700
-0.698113 -0.096122  21.48067    25813.    -19007.      9417.  4  1        00075800
-0.626843 -0.109507  23.48956    26575.    -13417.      8369.  4  1        00075900
-0.426601 -0.109109  25.20590    23828.     -8139.      7395.  4  1        00076000
-0.167066 -0.098368  26.42107    18661.     -4594.      6644.  4  1        00076100
 0.202025 -0.077966  27.44927    10738.     -1865.      5491.  4  1        00076200
 0.585465 -0.054988  27.84136     3624.      -479.      3558.  4  1        00076300
 1.000000 -0.029398  27.91078      -88.       -29.      1142.  4  1        00076400
                                                              15 324. 4 00076500
           AH-1G TAIL ROTOR GROUP      (OLS CORRELATION)                    00076600
2.0        .410       0.0        4.25       6.40       0.0        11.0      00076700
320.67     14.10      118.27     15.081     1.532      .251       0.0       00076800
0.0        0.0        10000.     0.0        0.0        0.0        .541      00076900
1.5        0.0        45.0       .12        0.0        0.0        .2        00077000
0.0        0.0        2.03       2.76       0.0        0.0        0.0       00077100
0.0        0.0        0.0        0.0        .25        0.0        .560      00077200
0.0        0.0        -90.0      0.0        0.0        0.0        0.0       00077300
0.0        0.0        0.0        0.0        0.0        0.0        0.0       00077400
           AH-1G M/R IN GROUP ONE, T/R IN GROUP TWO  (OLS CORRELATION)      00077500
.78        1.11       1.2323     .2964      -2.3074    1.540      .8        00077600
.1034      -.1029     .3846      -.2449     0.0        0.0        0.0       00077700
0.0        0.0        .0971      1.0        0.0        .2         1.0       00077800
0.0        0.0        0.0        0.0        0.0        0.0        0.0       00077900
0.0        0.0        0.0        0.0        0.0        0.003      0.0       00078000
.75        1.292      1.4916     .1263      -1.7286    .4167      .8        00078100
.108       -.1907     .8779      -.8663     0.0        0.0        0.0       00078200
0.0        0.0        .15        2.0        0.0        .2         1.0       00078300
0.0        0.0        0.0        0.0        0.0        0.0        0.0       00078400
0.0        0.0        0.0        0.0        0.0        0.0        0.0       00078500
           RIVD TABLE FOR AGAPBC, 3 ADVANCE RATIOS, 2 INFLOW RATIOS         00078600
FLT 35A, SIGMA-PRIME = 0.8636                 3  2  6                       00078700
0.2628     0.2925     0.3212                                                00078800
-0.04      -0.01                                                            00078900
   0.77379   0.02622  -0.26216  -0.38042   0.99633   0.01980  -0.21307     00079000
             0.30465   0.38995  -0.10281  -0.17137   0.13839  -0.06278     00079100
```

Figure 49. Continued.

0.61389	0.23738	0.09292	-0.37968	0.57576	0.16393	-0.10319	00079200
	0.08568	0.18343	-0.08498	-0.11261	0.05498	0.05440	00079300
0.60058	0.39385	0.22592	-0.33188	0.43402	0.29951	-0.00228	00079400
	0.05858	0.06431	-0.02701	-0.07879	0.08497	0.05892	00079500
0.44874	0.36540	0.42816	-0.19860	0.15767	0.19885	0.17773	00079600
	0.10416	-0.08085	-0.01999	0.02123	0.02325	-0.05771	00079700
0.35882	0.41317	0.52982	-0.20171	-0.03776	0.23021	0.30325	00079800
	0.05324	-0.16479	0.02530	0.03289	-0.04567	-0.03868	00079900
0.38155	0.42798	0.43293	-0.09690	-0.05857	0.16889	0.28029	00080000
	0.12338	-0.15073	-0.03139	-0.03121	-0.04497	-0.00325	00080100
0.38974	0.42222	0.44311	0.06953	-0.03881	0.18358	0.19142	00080200
	0.13948	-0.15148	-0.02182	-0.10033	-0.09378	-0.05315	00080300
0.32385	0.34066	0.41889	0.12340	-0.08341	0.08190	0.25709	00080400
	0.25735	-0.08757	-0.02492	-0.15927	-0.06095	-0.06849	00080500
0.28084	0.23392	0.32729	0.21395	-0.02779	0.10610	0.17462	00080600
	0.19839	-0.06850	-0.01044	-0.12128	-0.02272	-0.06535	00080700
0.33570	0.15858	0.46326	0.33009	-0.00041	-0.06961	0.05517	00080800
	0.04448	0.01693	-0.06874	-0.18304	-0.14377	-0.05075	00080900
0.42492	0.12305	0.44684	0.26823	0.01043	-0.12498	0.01793	00081000
	-0.02880	-0.02050	-0.05752	-0.19838	-0.11327	-0.10193	00081100
0.53004	0.07423	0.47934	0.17828	0.02348	-0.21107	-0.00543	00081200
	-0.08395	-0.05780	-0.03729	-0.23714	-0.07903	-0.14641	00081300
0.66226	-0.01705	0.54430	0.13102	0.11311	-0.24751	0.00928	00081400
	-0.16093	-0.04617	-0.05298	-0.17191	-0.03923	-0.11738	00081500
0.72359	-0.34287	0.75912	0.16622	0.46339	-0.18631	-0.03716	00081600
	-0.43076	-0.07300	-0.18942	0.05314	0.05031	-0.06358	00081700
0.89626	-0.34546	0.76704	0.14459	0.44433	-0.23219	0.00981	00081800
	-0.41650	-0.00537	-0.15129	0.09435	0.06694	-0.03498	00081900
1.15493	-0.44141	0.82085	0.04284	0.45156	-0.31628	0.05640	00082000
	-0.33400	0.00285	0.01785	-0.00455	0.18875	-0.15468	00082100
1.34511	-0.61906	0.71831	0.05109	0.49720	-0.22950	0.10630	00082200
	-0.26103	-0.06343	-0.03308	-0.07860	0.11499	-0.11007	00082300
1.81312	-1.01754	0.63626	-0.00233	0.48211	-0.14102	0.05144	00082400
	-0.13050	-0.17354	-0.03991	-0.10793	0.03132	-0.00454	00082500
1.63294	-0.77442	2.33077	-0.51703	0.43330	-0.03266	-0.44917	00082600
	0.07470	-0.11649	-0.10347	0.17125	-0.10258	-0.08125	00082700
3.19446	-1.07569	5.07166	-1.17876	1.86794	-0.64296	-0.77055	00082800
	0.05105	-1.29574	0.37712	-0.28513	0.21339	0.59558	00082900
0.77379	0.02622	-0.26218	-0.38042	0.99633	0.01986	-0.21307	00083000
	0.30485	0.38995	-0.10281	-0.17137	0.13839	-0.06278	00083100
0.61389	0.23738	0.09292	-0.37968	0.57576	0.16393	-0.10319	00083200
	0.08568	0.18343	-0.08498	-0.11261	0.05498	0.05440	00083300
0.60058	0.39385	0.22592	-0.33188	0.43402	0.29951	-0.00228	00083400
	0.05858	0.06431	-0.02701	-0.07879	0.08497	0.05892	00083500
0.44874	0.36540	0.42816	-0.19860	0.15767	0.19885	0.17773	00083600
	0.10416	-0.08085	-0.01999	0.02123	0.02325	-0.05771	00083700
0.35882	0.41317	0.52982	-0.20171	-0.03776	0.23021	0.30325	00083800
	0.05324	-0.16479	0.02530	0.03289	-0.04567	-0.03868	00083900
0.38155	0.42798	0.43293	-0.09690	-0.05857	0.16889	0.28029	00084000
	0.12338	-0.15073	-0.03139	-0.03121	-0.04497	-0.00325	00084100
0.38974	0.42222	0.44311	0.06953	-0.03881	0.18358	0.19142	00084200
	0.13948	-0.15148	-0.02182	-0.10033	-0.09378	-0.05315	00084300
0.32385	0.34066	0.41889	0.12340	-0.08341	0.08190	0.25709	00084400
	0.25735	-0.08757	-0.02492	-0.15927	-0.06095	-0.06849	00084500
0.28084	0.23392	0.32729	0.21395	-0.02779	0.10610	0.17462	00084600
	0.19839	-0.06850	-0.01044	-0.12128	-0.02272	-0.06535	00084700
0.33570	0.15858	0.46326	0.33009	-0.00041	-0.06961	0.05517	00084800
	0.04448	0.01693	-0.06874	-0.18304	-0.14377	-0.05075	00084900
0.42492	0.12305	0.44684	0.26823	0.01043	-0.12498	0.01793	00085000
	-0.02880	-0.02050	-0.05752	-0.19838	-0.11327	-0.10193	00085100
0.53004	0.07423	0.47934	0.17828	0.02348	-0.21107	-0.00543	00085200
	-0.08395	-0.05780	-0.03729	-0.23714	-0.07903	-0.14641	00085300
0.66226	-0.01705	0.54430	0.13102	0.11311	-0.24751	0.00928	00085400
	-0.16093	-0.04617	-0.05298	-0.17191	-0.03923	-0.11738	00085500
0.72359	-0.34287	0.75912	0.16622	0.46339	-0.18631	-0.03716	00085600
	-0.43076	-0.07300	-0.18942	0.05314	0.05031	-0.06358	00085700
0.89626	-0.34546	0.76704	0.14459	0.44433	-0.23219	0.00981	00085800
	-0.41650	-0.00537	-0.15129	0.09435	0.06694	-0.03498	00085900
1.15493	-0.44141	0.82085	0.04284	0.45156	-0.31628	0.05640	00086000
	-0.33400	0.00285	0.01785	-0.00455	0.18875	-0.15468	00086100
1.34511	-0.61906	0.71831	0.05109	0.49720	-0.22950	0.10630	00086200
	-0.26103	-0.06343	-0.03308	-0.07860	0.11499	-0.11007	00086300
1.81312	-1.01754	0.63626	-0.00233	0.48211	-0.14102	0.05144	00086400
	-0.13050	-0.17354	-0.03991	-0.10793	0.03132	-0.00454	00086500
1.63294	-0.77442	2.33077	-0.51703	0.43330	-0.03266	-0.44917	00086600
	0.07470	-0.11649	-0.10347	0.17125	-0.10258	-0.08125	00086700
3.19446	-1.07569	5.07166	-1.17876	1.86794	-0.64296	-0.77055	00086800
	0.05105	-1.29574	0.37712	-0.28513	0.21339	0.59558	00086900
0.70675	0.04946	0.07595	-0.79383	0.47443	0.08515	0.12748	00087000
	-0.19192	0.38547	0.07497	0.02644	0.06961	0.25137	00087100
0.60427	0.10364	0.35617	-0.58380	0.24218	0.12979	0.24894	00087200
	-0.09313	0.16613	0.09641	0.03343	-0.02689	0.08540	00087300
0.51828	0.14384	0.51130	-0.43934	0.03261	0.12897	0.36919	00087400
	0.00325	-0.01995	0.07617	0.06850	-0.05537	-0.04106	00087500
0.49981	0.15417	0.49228	-0.34884	-0.04343	0.06860	0.38835	00087600
	0.10126	-0.05033	0.01745	0.02405	-0.02964	-0.02681	00087700
0.50767	0.16966	0.44377	-0.29135	-0.07835	0.02390	0.38743	00087800
	0.17144	-0.04403	-0.01807	-0.03150	-0.02189	0.00573	00087900

Figure 49. Continued.

0.52812	0.20066	0.51603	-0.15457	-0.12581	-0.02347	0.46537	00088000
	0.37263	-0.03744	-0.05961	-0.11739	0.06858	0.05068	00088100
0.55290	0.22369	0.43136	-0.14791	-0.13689	-0.03211	0.43621	00088200
	0.35984	-0.02189	-0.05107	-0.14429	0.02623	0.05378	00088300
0.52050	0.14905	0.42236	-0.03770	-0.10078	-0.04656	0.30836	00088400
	0.26444	0.05130	0.05645	-0.11511	-0.00380	-0.04551	00088500
0.43944	-0.03544	0.54764	0.28643	0.02461	0.02463	0.04944	00088600
	0.16447	0.05681	0.08481	-0.15318	-0.07117	-0.08833	00088700
0.43497	-0.07394	0.43017	0.24609	0.01261	-0.00359	0.05141	00088800
	0.11192	0.09361	0.10622	-0.07969	-0.02013	-0.08162	00088900
0.42519	-0.14687	0.39386	0.31405	0.03664	0.00048	-0.03259	00089000
	0.02462	0.12959	0.16170	-0.01883	-0.00016	-0.14096	00089100
0.46281	-0.14829	0.33970	0.31065	0.02366	0.00633	-0.03294	00089200
	0.01048	0.11694	0.14459	-0.00363	0.01766	-0.12900	00089300
0.53959	-0.17603	0.28645	0.30350	0.02228	0.00899	-0.03885	00089400
	-0.03009	0.08647	0.10329	0.02230	0.05189	-0.11128	00089500
0.60143	-0.30729	0.30227	0.31942	0.11769	0.04752	-0.08720	00089600
	-0.14315	0.00952	0.01757	0.09281	0.12752	-0.08395	00089700
0.79075	-0.33081	0.34166	0.27140	0.11146	-0.06280	-0.05950	00089800
	-0.20450	0.03378	-0.00681	0.06929	0.10165	-0.12075	00089900
1.06023	-0.43308	0.45287	0.24999	0.20067	-0.09469	-0.02294	00090000
	-0.23455	-0.02358	-0.08413	-0.02038	0.01160	-0.14691	00090100
1.28637	-0.76415	0.45185	0.16077	0.40718	-0.03198	0.10628	00090200
	-0.18330	-0.12518	-0.19503	-0.13310	-0.10123	-0.07156	00090300
1.81061	-1.16305	0.43733	0.13936	0.50741	-0.01332	0.17082	00090400
	-0.16060	-0.16736	-0.25117	-0.17207	-0.14987	-0.02106	00090500
1.67145	-0.97123	2.33607	-0.62477	0.40128	0.02769	-0.46535	00090600
	0.09605	-0.12176	-0.25743	0.19657	-0.29081	-0.01721	00090700
3.29961	-1.32699	5.18979	-1.41799	1.88932	-0.72145	-0.81998	00090800
	0.04432	-1.36444	0.30869	-0.27626	0.09345	0.70386	00090900
0.70675	0.04946	0.07595	-0.79383	0.47443	0.38515	0.12748	00091000
	-0.19192	0.38547	0.07497	0.02644	0.06961	0.25137	00091100
0.60427	0.10364	0.35617	-0.58380	0.24218	0.12479	0.24894	00091200
	-0.09313	0.16613	0.09641	0.03343	-0.02689	0.08540	00091300
0.51828	0.14384	0.51130	-0.43934	0.03261	0.12897	0.36919	00091400
	0.00325	-0.01995	0.07617	0.06850	-0.05537	-0.04106	00091500
0.49961	0.15417	0.49228	-0.34884	-0.04343	0.06960	0.38835	00091600
	0.10126	-0.05033	0.01745	0.02405	-0.02964	-0.02681	00091700
0.50767	0.16968	0.44377	-0.29135	-0.07835	0.02390	0.38743	00091800
	0.17144	-0.04403	-0.01867	-0.03150	-0.02189	0.00573	00091900
0.52812	0.20066	0.51603	-0.15457	-0.12581	-0.02347	0.46537	00092000
	0.37263	-0.03744	-0.05961	-0.11739	0.06858	0.05068	00092100
0.55290	0.22369	0.43136	-0.14791	-0.13689	-0.03211	0.43621	00092200
	0.35984	-0.02189	-0.05107	-0.14429	0.02623	0.05378	00092300
0.52050	0.14905	0.42236	-0.03770	-0.10078	-0.04656	0.30836	00092400
	0.26444	0.05130	0.05645	-0.11511	-0.00380	-0.04551	00092500
0.43944	-0.03544	0.54764	0.28643	0.02461	0.02463	0.04944	00092600
	0.16447	0.05681	0.08481	-0.15318	-0.07117	-0.08833	00092700
0.43497	-0.07394	0.43017	0.24609	0.01261	-0.00359	0.05141	00092800
	0.11192	0.09361	0.10622	-0.07969	-0.02013	-0.08162	00092900
0.42519	-0.14687	0.39386	0.31405	0.03664	0.00048	-0.03259	00093000
	0.02462	0.12959	0.16170	-0.01883	-0.00016	-0.14096	00093100
0.46281	-0.14829	0.33970	0.31065	0.02366	0.00633	-0.03294	00093200
	0.01048	0.11694	0.14459	-0.00363	0.01766	-0.12900	00093300
0.53959	-0.17603	0.28645	0.30350	0.02228	0.00899	-0.03885	00093400
	-0.03009	0.08647	0.10329	0.02230	0.05189	-0.11128	00093500
0.60143	-0.30729	0.30227	0.31942	0.11769	0.04752	-0.08720	00093600
	-0.14315	0.00952	0.01757	0.09281	0.12752	-0.08395	00093700
0.79075	-0.33081	0.34166	0.27140	0.11146	-0.06280	-0.05950	00093800
	-0.20450	0.03378	-0.00681	0.06929	0.10165	-0.12075	00093900
1.06023	-0.43308	0.45287	0.24999	0.20067	-0.09469	-0.02294	00094000
	-0.23455	-0.02358	-0.08413	-0.02038	0.01160	-0.14691	00094100
1.28637	-0.76415	0.45185	0.16077	0.40718	-0.03198	0.10628	00094200
	-0.18330	-0.12518	-0.19503	-0.13310	-0.10123	-0.07156	00094300
1.81061	-1.16305	0.43733	0.13936	0.50741	-0.01332	0.17082	00094400
	-0.16060	-0.16736	-0.25117	-0.17207	-0.14987	-0.02106	00094500
1.67145	-0.97123	2.33607	-0.62477	0.40128	0.02769	-0.46535	00094600
	0.09605	-0.12176	-0.25743	0.19657	-0.29081	-0.01721	00094700
3.29961	-1.32699	5.18979	-1.41799	1.88932	-0.72145	-0.81998	00094800
	0.04432	-1.36444	0.30869	-0.27626	0.09345	0.70386	00094900
0.66733	0.02692	0.09839	-0.85265	-0.00137	0.02467	0.15788	00095000
	-0.39280	-0.07709	0.00215	0.15526	-0.15322	-0.06747	00095100
0.64657	0.04575	0.25106	-0.73964	-0.04664	-0.01739	0.34076	00095200
	-0.21831	-0.07500	-0.07082	0.21965	-0.02229	-0.00976	00095300
0.56189	-0.01626	0.50162	-0.45704	-0.13107	-0.17265	0.44110	00095400
	0.05883	0.02998	-0.10806	0.12043	0.05757	0.09598	00095500
0.57623	0.01645	0.54200	-0.33224	-0.13080	-0.17096	0.46948	00095600
	0.20326	0.06651	-0.07098	0.04586	0.10356	0.11092	00095700
0.60676	0.04849	0.51133	-0.27976	-0.12138	-0.14750	0.46669	00095800
	0.20180	0.08764	-0.03114	-0.00111	0.10656	0.10598	00095900
0.49834	-0.13099	0.06291	0.00662	-0.07283	-0.23304	0.24542	00096000
	0.20833	0.26932	0.14125	-0.07372	0.00869	0.02702	00096100
0.52556	-0.10483	0.56744	0.01756	-0.07490	-0.20944	0.22431	00096200
	0.19457	0.25875	0.15830	-0.07098	0.00491	-0.00675	00096300
0.51271	-0.14793	0.56398	0.10559	-0.05653	-0.20305	0.12365	00096400
	0.12062	0.29665	0.23956	-0.04530	-0.01429	-0.10652	00096500
0.47343	-0.27511	0.54481	0.20684	0.07026	-0.07098	0.00128	00096600
	0.00841	0.19782	0.19281	0.03986	0.05266	-0.10836	00096700

Figure 49. Continued.

```
0.51714   -0.25103   0.49463   0.22255   0.05812  -0.03952  -0.00954   00096800
           0.00709   0.15804   0.16600   0.03155   0.04812  -0.10488   00096900
0.56443   -0.23504   0.44552   0.23744   0.04204  -0.01599  -0.01760   00097000
           0.00486   0.12619   0.14141   0.02781   0.04821  -0.09785   00097100
0.60402   -0.23120   0.39906   0.23965   0.02117  -0.01445  -0.01656   00097200
           0.00254   0.11883   0.13147   0.03020   0.05112  -0.09161   00097300
0.61733   -0.35448   0.35788   0.29458   0.09746   0.07916  -0.08105   00097400
          -0.08030   0.03341   0.05874   0.12011   0.14322  -0.04124   00097500
0.65752   -0.45770   0.28639   0.26813   0.14697   0.13977  -0.02746   00097600
          -0.02015  -0.02355   0.00864   0.04880   0.06815  -0.00795   00097700
0.77171   -0.50354   0.23313   0.27513   0.12475   0.12888  -0.01477   00097800
          -0.01466  -0.02382   0.00072   0.03206   0.04846  -0.00805   00097900
0.95514   -0.59936   0.18602   0.28630   0.11083   0.11198  -0.00304   00098000
          -0.02058  -0.02538  -0.01633   0.01814   0.02608  -0.01047   00098100
1.22426   -0.76334   0.13215   0.31166   0.11801   0.09060   0.01793   00098200
          -0.03988  -0.03399  -0.04176   0.00036   0.00333  -0.01208   00098300
1.74560   -1.18968   0.08468   0.34617   0.21286   0.15438   0.06687   00098400
          -0.00990  -0.11795  -0.14003  -0.08160  -0.10911   0.00591   00098500
1.57376   -0.97061   2.05420  -0.53954   0.12359   0.19782  -0.57775   00098600
           0.25611  -0.05911  -0.18821   0.29318  -0.31025  -0.00864   00098700
3.22056   -1.37892   4.96860  -1.43562   1.67064  -0.64876  -0.91338   00098800
           0.18176  -1.32230   0.41546  -0.19508   0.09218   0.72437   00098900
0.66733    0.02692   0.09839  -0.85265  -0.00137   0.02467   0.15788   00099000
          -0.39280  -0.07709   0.00215   0.15526  -0.15322  -0.06747   00099100
0.64857    0.04575   0.25108  -0.73964  -0.04664  -0.01739   0.34076   00099200
          -0.21831  -0.07500  -0.07082   0.21965  -0.02229  -0.00976   00099300
0.56189   -0.01626   0.50162  -0.45704  -0.13107  -0.17265   0.44110   00099400
           0.05883   0.02998  -0.10806   0.12043   0.05757   0.09598   00099500
0.57023    0.01045   0.54200  -0.33224  -0.13080  -0.17096   0.46949   00099600
           0.20326   0.06651  -0.07098   0.04586   0.10350   0.11092   00099700
0.60676    0.04649   0.51133  -0.27976  -0.12138  -0.14750   0.46689   00099800
           0.26180   0.08704  -0.03114  -0.00111   0.10656   0.10598   00099900
0.49834   -0.13099   0.62291   0.00662  -0.07283  -0.23304   0.24542   00100000
           0.20833   0.26932   0.14125  -0.07372   0.00869   0.02702   00100100
0.52556   -0.10483   0.56744   0.01756  -0.07490  -0.20944   0.22431   00100200
           0.19457   0.25875   0.15830  -0.07098   0.00491  -0.00675   00100300
0.51271   -0.14793   0.56396   0.10559  -0.05050  -0.20305   0.12365   00100400
           0.12002   0.29685   0.23950  -0.04530  -0.01429  -0.10652   00100500
0.47343   -0.27511   0.54481   0.20684   0.07026  -0.07098   0.00128   00100600
           0.00841   0.19782   0.19281   0.03986   0.05266  -0.10836   00100700
0.51714   -0.25103   0.49463   0.22255   0.05812  -0.03952  -0.00954   00100800
           0.00709   0.15804   0.16600   0.03155   0.04812  -0.10488   00100900
0.56443   -0.23504   0.44552   0.23744   0.04204  -0.01599  -0.01760   00101000
           0.00486   0.12619   0.14141   0.02781   0.04821  -0.09785   00101100
0.60432   -0.23120   0.39906   0.23965   0.02117  -0.01445  -0.01656   00101200
           0.00254   0.11883   0.13147   0.03020   0.05112  -0.09161   00101300
0.61733   -0.35448   0.35788   0.29458   0.09746   0.07916  -0.08105   00101400
          -0.08030   0.03341   0.05874   0.12011   0.14322  -0.04124   00101500
0.65752   -0.45770   0.28639   0.26813   0.14697   0.13977  -0.02746   00101600
          -0.02015  -0.02355   0.00864   0.04880   0.06815  -0.00795   00101700
0.77171   -0.50354   0.23313   0.27513   0.12475   0.12888  -0.01477   00101800
          -0.01466  -0.02382   0.00072   0.03206   0.04846  -0.00805   00101900
0.95514   -0.59936   0.18602   0.28630   0.11683   0.11198  -0.00304   00102000
          -0.02058  -0.02538  -0.01633   0.01814   0.02608  -0.01047   00102100
1.22426   -0.76334   0.13215   0.31166   0.11801   0.09060   0.01793   00102200
          -0.03988  -0.03399  -0.04176   0.00036   0.00333  -0.01208   00102300
1.74560   -1.18968   0.08468   0.34617   0.21286   0.15438   0.06687   00102400
          -0.00990  -0.11795  -0.14003  -0.08160  -0.10911   0.00591   00102500
1.57376   -0.97061   2.05420  -0.53954   0.12359   0.19782  -0.57775   00102600
           0.25611  -0.05911  -0.18821   0.29318  -0.31025  -0.00864   00102700
3.22056   -1.37892   4.96860  -1.43562   1.67064  -0.64876  -0.91338   00102800
           0.18176  -1.32230   0.41546  -0.19508   0.09218   0.72437   00102900
          AH-1G BASIC FUSELAGE GRP  BASELINE W/INSTRUMENTATION
8319.0    200.0     0.0       71.2      200.6     0.0       68.0       00103000
2904.0    11883.4   10233.5   -585.0    0.0       30.       45.        00103100
0.0                                                                    00103200
0.0                                                                    00103300
0.0                                                                    00103400
          AH-1G FUSELAGE AERODYNAMIC GROUP                             00103500
0.0       0.0       0.0       0.0       0.0       0.0       -.016492   00103600
-.017945  .32       -.001903  -.0013    .0025     -.000153  -.000305   00103700
5.5       0.0       0.0       0.0       59.0      59.0      .024159    00103800
.03       .032      .0        .0005     .01       .0        -.0003     00103900
-27.0     0.0       0.0       0.0       0.0       0.0       -.001883   00104000
.30545    4.0       .0        .03       -.01      .0        -.0025     00104100
0.0       0.0       0.0       1.6       0.0       -.015     0.0        00104200
2.4       .05       .003      -.028667  .0        -.010832  .0         00104300
.0        .0        .0        -4.7058   -.65      .045      .001       00104400
-.4       -.18      .0        .0        .0        .0        .0         00104500
.0        .0        .0        -3.5      -.85      -.06      .011       00104600
17.57     .0        .0        .014533   .0        -.015293  .0         00104700
          AH-1G WING GROUP                                             00104800
28.15     189.73    28.53     68.28     14.0      3.24      11.43      00104900
3.86      .98       .588      0.0       0.0       0.0       0.0        00105000
0.0       0.0       0.0       0.0       0.0       0.0       0.0        00105100
0.0       0.0       0.0       0.0       0.0       0.0       0.0        00105200
0.0       0.0       0.0       0.0       0.0       0.0       0.0        00105300
0.0       0.0       0.0       0.0       0.0       0.0       0.0        00105400
0.0       0.0       0.0       0.0       0.0       0.0       0.0        00105500
```

Figure 49. Continued.

```
.84      1.25     1.2      0.0      0.0      0.0      1.1          00105600
.107     0.0      .0535    0.0      .01      0.0      .000333      00105700
0.0      .2       .27      0.0      0.0      0.0      0.0          00105800
-.002    -.009    .82      0.0      0.0      0.0      0.0          00105900
                                                                   00106000
         AH-1G VERTICAL STABILIZER GROUP    (OLS CORRELATION)      00106100
18.87    501.1    0.0      97.18    4.5      90.0     47.59        00106200
1.62     .99      .48      0.0      0.0      0.0      0.0          00106300
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00106400
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00106500
0.0      0.0      0.0      0.0      0.0      0.0      1.2          00106600
.84      1.25     1.20     0.0      0.0      0.0      .000137      00106700
.1       0.0      .05      0.0      .008     0.0      0.0          00106800
.04      .2       .15      0.0      .0332    0.0      0.0          00106900
-.002    -.009    .82      -.005    0.0      0.0      0.0          00107000
         AH-1G R/H HORIZONTAL STABILIZER GROUP    (OLS CORRELATION)00107100
7.57     397.5    18.62    55.66    .697     0.0      16.28        00107200
1.49     .98      .66      0.0      0.0      1.0      0.0          00107300
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00107400
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00107500
         -1.0     -1.0                                             00107600
.84      1.25     1.2      0.0      0.0      0.0      1.2          00107700
.097     0.0      .0435    0.0      .008     0.0      .0003284     00107800
.04      .20      .15      0.0      .0332    0.0      0.0          00107900
-.002    -.009    .82      .07      0.0      0.0      0.0          00108000
0.0      0.0      0.0      .432858  .220569  0.0      0.0          00108100
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00108200
         AH-1G L/H HORIZONTAL STABILIZER GROUP    (OLS CORRELATION)00108300
7.57     397.5    -18.62   55.66    .697     0.0      16.28        00108400
1.49     .98      .66      0.0      0.0      1.0      0.0          00108500
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00108600
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00108700
         -1.0     -1.0     0.0      0.0      0.0      0.0          00108800
.84      1.25     1.2      0.0      0.0      0.0      1.2          00108900
.087     0.0      .0435    0.0      .008     0.0      .0003284     00109000
.04      .20      .15      0.0      .0332    0.0      0.0          00109100
-.002    -.009    .82      .07      0.0      0.0      0.0          00109200
0.0      0.0      0.0      .432858  .220569  0.0      0.0          00109300
0.0      0.0      0.0      0.0      0.0      0.0      0.0          00109400
         AH-1G CONTROLS GROUP  S/N 20391  (OLS CORRELATION)        00109500
10.0     7.8      19.8                                             00109600
12.0     -15.6    30.0                                             00109700
12.0     -11.0    16.87                                            00109800
6.5      10.0     -28.17   0.0      0.0      0.0      0.0          00109900
          ITERATION LIMITS GROUP                                   00110000
41.0     10.0     0.5      0.5      3.0      7.0      .3           00110100
0.0                                                                00110200
0.0                                                                00110300
0.0                                                                00110400
0.0                                                                00110500
0.0                                                                00110600
0.0                                                                00110700
25.0     25.0     5.0      5.0      25.0     25.0     5.0          00110800
25.      25.      25.      25.0                                    00110900
0.0                                                                00111000
0.0                                                                00111100
         OLS FLIGHT CONSTANTS GROUP                                00111200
129.3                      1000.0   -1.2     -3.2     -1.232       00111300
35.0     70.0     55.0     750.0                                   00111400
-2.0     -0.5     -1.1     1.0      7450.0   -250.0                00111500
                  1250.0   6600.0   -1.0     2900.0   27.0         00111600
10                                                                 00111700
 &CHANGE  IPL(12)=0.IPL(48)=-1.IPL(71)=2.IPL(75)=3    &END         00111800
10                                                                 00111900
 &CHANGE  IPL(48)=1.   &END                                        00112000
10          1                                                      00112100
 &CHANGE  IPL(48)=0.    &END                                       00112200
14                                                                 00112300
 3    1                                              200.0         00112400
   353   360   320    1                              200.0         00112500
   367   374   320    1                              200.0         00112600
   381   388   320    1                              200.0         00112700
   395   402   320    1                              200.0         00112800
   409  1508   320    1                              200.0         00112900
  1509  1510   320    1                      200.0                 00113000
 /1511   320          1                        0                   00113100
 9              13        .925 1.296    0                          00113200
 / 353   360   367   374   381   388   395   402   409 1508 1509 1510 1511  00113300
12      1     1        1       1.111                               00113400
/       1     2                                                    00113500
15      5     3                                                    00113600
NEW SAMPLPRT PASS AUSTIN                                           00113700
SPACE 0009 USER VG                                                 00113800
RATE 256 RECORD 1.296                                              00113900
ALL ITEMS ALL COUNTERS                                             00114000
END                                                                00114100
 BRMI CHMI TBMI                                                    00114200
/ 133  144  154  173  233  234  235  244  253  262  271  321       00114300
14
```

Figure 49. Continued.

```
 3    1                                                                             00114400
  353   360   320     1                                      200.0                  00114500
  367   374   320     1                                      200.0                  00114600
  381   388   320     1                                      200.0                  00114700
  395   402   320     1                                      200.0                  00114800
  409  1508   320     1                                      200.0                  00114900
 1509  1510   320     1                                      200.0                  00115000
/1511   320           1                               200.0                         00115100
 9                13       .925 1.296     0             0                           00115200
/ 353   360   367   374   381   388   395   402   409  1508  1509  1510  1511       00115300
15     C     3                                                                      00115400
 RBM1  CHM1  TBM1                                                                   00115500
/ 133   144   154   173   233   234   235   244   253   262   271   321             00115600
14                                                                                  00115700
 3    1                                                                             00115800
  353   360   320     1                                      200.0                  00115900
  367   374   320     1                                      200.0                  00116000
  381   388   320     1                                      200.0                  00116100
  395   402   320     1                                      200.0                  00116200
  409  1506   320     1                                      200.0                  00116300
 1509  1510   320     1                                      200.0                  00116400
/1511   320           1                               200.0                         00116500
 9                13       .925 1.296     0             0                           00116600
/ 353   360   367   374   381   388   395   402   409  1508  1509  1510  1511       00116700
15     C     3                                                                      00116800
 SBM1  CBM1  TBM1                                                                   00116900
/ 133   144   154   173   233   234   235   244   253   262   271   321             00117000
```

Figure 49. Concluded.

USER MESSAGES FOR AGAP8001 (05-16-80)

```
THE AGAP8001 VERSION OF C81 DIFFERS FROM THE CURRENT PRODUCTION
VERSION (AGAJ7625) IN THAT

        (1) IT ALLOWS THE POSTPROCESSING OF TRIM DATA IN GDAP80.
        (2) IPL(1) HAS MANY MORE ACCEPTABLE VALUES.
        (3) THE ROTOR 1 GROUP IS FOLLOWED BY THE ROTOR 1 ELASTIC PYLON
            GROUP IF IPL(9) IS NOT EQUAL TO 0. THERE CAN BE UP TO
            10 ELASTIC PYLON MODES IN THIS GROUP, I.E.
                      -11 < IPL(9) < 11
        (4) THE ROTOR 2 GROUP IS FOLLOWED BY THE ROTOR 2 ELASTIC PYLON
            GROUP IF IPL(10) IS NOT EQUAL TO 0. THERE CAN BE UP TO
            10 ELASTIC PYLON MODES IN THIS GROUP, I.E.
                      -11 < IPL(10) < 11
        (5) THE FUSELAGE GROUP HAS BEEN DIVIDED INTO TWO GROUPS, WITH
            THE SECOND GROUP BEING EITHER THE FUSELAGE AERODYNAMIC
            EQUATIONS GROUP (IPL(29)=0) OR THE FUSELAGE AERODYNAMIC
            TABLES GROUP (IPL(29) NE 0).
        (6) THE ITERATION LOGIC GROUP HAS 56 ADDITIONAL INPUTS.
        (7) THE IMPROVED MANEUVER AUTOPILOT AND DIGITAL FILTER
            HAVE BEEN INSTALLED.
        (8) THE USER MAY INPUT UP TO 10 AERODYNAMIC TABLES AND UP
            TO 10 ROTOR AERODYNAMIC SUBGROUPS.  NOTE THAT THE INPUT
            FORMAT FOR THE IDTABM AND IDTABT ARRAYS IS NOW 2012
            INSTEAD OF 2011.
        (9) THE DIGITAL FILTER AND THE IMPROVED MANEUVER AUTOPILOT
            HAVE BEEN INSTALLED IN AGAP80.

A NEW LISTING OF THE CONTENTS OF THE ANALYTICAL DATA BASE WILL BE
GENERATED DURING THE WEEK OF 19 MAY.
```

Figure 50. User Messages.

BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001   COMPUTED 06/19/81

AH-1G + OLS ROTOR SIMULATION   AGAP80 ARMY VERSION
OLS COUNTER 615. FLIGHT 35A. 2900' HP, 27 DEG C (PAN NAME C818RMT
ELASTIC ROTOR. HSOFT = -17.0   OUTPUT TO GO INTO INPUT GUIDE

INPUT DATA

OLS PROGRAM LOGIC GROUP

PROGRAM LOGIC GROUP

0	2	0	-20	5	9	0	0	0	0	2	1	0	0
-1	-1	1	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	5	1	2	0	1	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	1	1	0	6	0	0	0	0	0	0	0
0	0	3	0	0	0	0	0	0	0	0	0	0	0

MODEL 209 M/R AIRFOIL DATA TABLE

NACA 0015 AS PROVIDED BY PAI (03-19-77)

AH-1G MAIN ROTOR GROUP 209 ROTOR WITH OLS INSTR.

MAIN ROTOR GROUP

2.000000	4.500000	101.6000	22.00000	.0	-10.00000	12.00000
200.0000	.0	152.7600	475.6001	1385.080	.4910000E-01	.0
1.000000	.0	18099.00	.0	1.000000	.0	3.400000
2.750000	.0	.0	.1300000	.0	.0	.0
.0	.0	-9.067000	14.10000	.0	.0	-.6820000
.0	.0	.0	.0	2.000002	-.7590000	100.5500
.0	.0	.0	.0	.0	.0	.0
5.400000	.0	.0	.0	.0	.0	.0
6.000000	20.57500	37.50000	52.80000	66.00000	81.50000	92.39999
103.0000	118.8000	132.0000	145.2000	155.8000	171.6000	184.8000
198.0000	212.3000	224.4000	238.1000	250.6000	264.0000	.0
.0	.0	.0	.0	.0	.0	-.2812500
-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	-.2812500
-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	-.2812500	.0
14.00000	19.60001	8.200000	27.00000	27.00000	27.00000	28.62500
28.62500	28.62500	28.62500	28.62500	28.62500	28.62500	28.62500
28.62500	28.62500	28.62500	28.62500	28.62500	28.62500	.0

540279 26 SEG OLS MR PRECONE AND UNDERSLING HSOFT = -17.2

AH-1G TAIL ROTOR GROUP (OLS CORRELATION)

TAIL ROTOR GROUP

2.000000	.4100000	.0	4.250000	8.400000	.0	11.08000
520.6699	14.10000	118.2700	15.08100	1.532000	.2510000	.0
.0	.0	10000.00	.0	.0	.0	.5410000
1.500000	.0	45.00000	.1200000	.0	.0	.2000000
.0	.0	2.030000	2.760000	.0	.0	.0
.0	.0	.0	.0	.2500000	.0	.5660000
.0	.0	-90.00000	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0

Figure 51. Problem Identification and Basic Input Groups.

AH-1G M/R IN GROUP ONE, T/R IN GROUP TWO (OLS CORRELATION)

RTR AERODYNAMIC GROUP

.7800000	1.110000	1.232300	.2964000	-2.307400	1.540000	.8600000
.1084000	-.1029000	.3646000	-.2449000	.0	.0	.0
.0	.0	.9710002E-01	1.000000	.0	.2000000	1.000000
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.3000000E-02	.0
.7500000	1.292000	1.491600	.1263000	-1.728600	.4167000	.8000000
.1080000	-.1907000	.8779000	-.8683000	.0	.0	.0
.0	.0	.1500000	2.000000	.0	.2000000	1.000000
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0

RIVD TABLE FOR AGAP80, 3 ADVANCE RATIOS, 2 INFLOW RATIOS

AH-1G BASIC FUSELAGE GRP BASELINE W/INSTRUMENTATION

FUSELAGE GROUP

8319.000	200.1000	.0	71.20000	200.6000	.0	68.00000
2904.000	11883.40	16233.50	-585.0000	.0	36.00000	45.00000
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
0	.0	.0	.0	.0	.0	.0

AH-1G FUSELAGE AERODYNAMIC GROUP

FLGE AERODYNAMIC GROUP

.0	.0	.0	.0	.0	.0	-.1649200E-01
-.1794500E-01	.3200000	-.1903000E-02	-.1300000E-02	.2500000E-02	-.1530000E-03	-.3056000E-03
5.500000	.0	.0	.0	59.00000	59.00000	.2415900E-01
.3000000E-01	.3200000E-01	.0	.5000001E-03	.1000000E-01	.0	-.3000000E-03
-27.00000	.0	.0	.0	.0	.0	-.1883000E-02
.3054500	4.000000	.0	.3000000E-01	-.1000000E-01	.0	-.2500000E-02
.0	.0	.0	1.600000	.0	-.1500000E-01	.0
2.400000	.5000000E-01	.3000000E-02	-.2666700E-01	.0	-.1083200E-01	.0
.0	.0	.0	-4.705800	-.6500000	.4500000E-01	.9999999E-03
-.4000000	-.1800000	.0	.0	.0	.0	.0
.0	.0	.0	-3.530000	-.8500000	-.6000000E-01	.1100000E-01
17.57001	.0	.0	.1453300E-01	.0	-.1529300E-01	.0

AH-1G WING GROUP

WING GROUP

28.14999	189.7300	28.53000	68.28000	14.60000	3.240000	11.43000
3.860000	.9800000	.5880000	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.8460000	1.250000	1.200000	.0	.0	.0	1.160000
.1070000	.0	.5350000E-01	.0	.1000000E-01	.0	.3330000E-03
.0	.2000000	.2700000	.0	.0	.0	.0
-.2000000E-02	-.9000000E-02	.8200000	.0	.0	.0	.0

AH-1G VERTICAL STABILIZER GROUP (OLS CORRELATION)

STABILIZER NO. 1 GROUP

18.87000	501.1001	.0	97.17999	4.500000	90.00000	47.59000
1.620000	.9900000	.4800000	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.8400000	1.250000	1.200000	.0	.0	.0	1.240000
.1000000	.0	.5000000E-01	.0	.8000001E-02	.0	.1370000E-03
.4000000E-01	.2000000	.1500000	.0	.3320000E-01	.0	.0
-.2000000E-02	-.9600000E-02	.8200000	-.4999999E-02	.0	.0	.0

Figure 51. Continued.

AH-1G R/H HORIZONTAL STABILIZER GROUP (OLS CORRELATION)

STABILIZER NO. 2 GROUP

7.570000	397.5000	18.62000	55.66000	.6970000	.0	16.28000
1.490000	.9420000	.6600000	.0	.0	1.000000	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	-1.000000	-1.000000	.0	.0	.0	.0
.8400000	1.250000	1.200000	.0	.0	.0	1.266000
.8720000E-01	.0	.4350000E-01	.0	.8000001E-02	.0	.3283999E-03
.4000000E-01	.2000000	.1500000	.0	.3320000E-01	.0	.0
-.2000000E-02	-.9000000E-02	.8200000	.6999999E-01	.0	.0	.0
.0	.0	.0	.4328580	.2205690	.0	.0
.0	.0	.0	.0	.0	.0	.0

AH-1G L/H HORIZONTAL STABILIZER GROUP (OLS CORRELATION)

STABILIZER NO. 3 GROUP

7.570000	397.5000	-18.62000	55.66000	.6970000	.0	16.28000
1.490000	.9800000	.6600000	.0	.0	1.000000	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	-1.000000	-1.000000	.0	.0	.0	.0
.8400000	1.250000	1.200000	.0	.0	.0	1.266000
.8720000E-01	.0	.4350000E-01	.0	.8000001E-02	.0	.3283999E-03
.4000000E-01	.2000000	.1500000	.0	.3320000E-01	.0	.0
-.2000000E-02	-.9000000E-02	.8200000	.6999999E-01	.0	.0	.0
.0	.0	.0	.4328580	.2205690	.0	.0
.0	.0	.0	.0	.0	.0	.0

AH-1G CONTROLS GROUP S/N 20391 (OLS CORRELATION)

CONTROLS GROUP

10.00000	7.800000	19.80000	.0	.0	.0	.0
12.00000	-15.60000	30.60001	.0	.0	.0	.0
17.00000	-11.00000	16.87000	.0	.0	.0	.0
6.500000	10.00000	-28.17000	.0	.0	.0	.0

ITERATION LIMITS GROUP

ITERATION GROUP

41.00000	10.00000	.5000000	.5000000	3.000000	7.000000	.3000000
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0
25.00000	25.00000	5.000000	5.000000	.0	.0	.0
25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	5.000008
.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0

OLS FLIGHT CONSTANTS GROUP

FLIGHT CONSTANTS GROUP

129.3000	.0	.0	1000.000	-1.200000	-3.200000	-1.232000
35.00000	76.00000	55.00000	50.00000	.0	.0	.0
-2.000000	-.5000000	-1.100000	1.000000	7450.000	-250.0000	.0
.0	.0	1250.000	6600.000	-1.[illegible]	2900.000	27.00000

TRIM OPTION	DOF
STANDARD TRIM	16

Figure 51. Continued.

SUPER 540 EXT'DSUPER 540 EXT'D CL TABLE

ALPHA/MACH	0.0	0.30000	0.50000	0.60000	0.65000	0.70000	0.75000	0.80000	0.85000	0.90000	1.00000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-172.00000	0.78000	0.75000	0.75000	0.78000	0.75000	0.78000	0.78000	0.78000	0.78000	0.78000	0.78000
-161.00000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000
-147.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-139.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
-49.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-39.00000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000	-1.18000
-21.00000	-0.93000	-0.81000	-0.85000	-0.85000	-0.85000	-0.85000	-0.71500	-0.68000	-0.66400	-0.64000	-0.64100
-18.00000	-0.88800	-0.85800	-0.88200	-0.87000	-0.87000	-0.86400	-0.75400	-0.72200	-0.69800	-0.67000	-0.66800
-14.00000	-1.17000	-1.17000	-0.92800	-0.87100	-0.87200	-0.85300	-0.84100	-0.86100	-0.76700	-0.72800	-0.72600
-12.50000	-1.22000	-1.22000	-0.95500	-0.86700	-0.86700	-0.85900	-0.84000	-0.81600	-0.77600	-0.74000	-0.73700
-11.00000	-1.18000	-1.18000	-0.93400	-0.86200	-0.86000	-0.82900	-0.83200	-0.81200	-0.77700	-0.74000	-0.72600
-10.00000	-1.07000	-1.07000	-0.93000	-0.85300	-0.85400	-0.81500	-0.82000	-0.80300	-0.77000	-0.73400	-0.70500
-9.00000	-0.96800	-0.96800	-0.92000	-0.83600	-0.84000	-0.80500	-0.80100	-0.78100	-0.75200	-0.71800	-0.67200
-8.00000	-0.88000	-0.80000	-0.89000	-0.81300	-0.81900	-0.77800	-0.78000	-0.75300	-0.73000	-0.69000	-0.63200
-7.00000	-0.75300	-0.75300	-0.83000	-0.78400	-0.76500	-0.75400	-0.74200	-0.72000	-0.70400	-0.65200	-0.56100
-6.00000	-0.64500	-0.64500	-0.71000	-0.74500	-0.72200	-0.72100	-0.67900	-0.67200	-0.66600	-0.60100	-0.52000
-4.00000	-0.43000	-0.43000	-0.47400	-0.52400	-0.55000	-0.58900	-0.56500	-0.56000	-0.52000	-0.45000	-0.36000
-2.00000	-0.21500	-0.21500	-0.23700	-0.26200	-0.27800	-0.29800	-0.31200	-0.31200	-0.26000	-0.22500	-0.18000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00000	0.21500	0.21500	0.23700	0.26200	0.27800	0.29800	0.31200	0.31200	0.26000	0.22500	0.18000
4.00000	0.43000	0.43000	0.47400	0.52400	0.55000	0.58900	0.56500	0.56000	0.52000	0.45000	0.36000
6.00000	0.64500	0.64500	0.71000	0.74500	0.72200	0.72100	0.67900	0.67200	0.66800	0.60100	0.52000
7.00000	0.75300	0.75300	0.83100	0.78400	0.78500	0.75400	0.74200	0.72000	0.70400	0.65200	0.56100
8.00000	0.86000	0.86000	0.89000	0.81300	0.81900	0.77800	0.78000	0.75300	0.73000	0.69000	0.63200
9.00000	0.96800	0.96800	0.92000	0.83600	0.84000	0.80500	0.80100	0.78100	0.75200	0.71800	0.67200
10.00000	1.07500	1.07500	0.93300	0.85300	0.85400	0.81500	0.82000	0.80300	0.77000	0.73400	0.70500
11.00000	1.14400	1.16400	0.93400	0.86200	0.86000	0.82900	0.83200	0.81200	0.77700	0.74000	0.72600
12.50000	1.22000	1.22000	0.93500	0.86700	0.86700	0.83900	0.84000	0.81800	0.77800	0.74000	0.73700
14.00000	1.17200	1.17200	0.92800	0.87100	0.87200	0.85300	0.84100	0.80100	0.76700	0.72800	0.72600
18.00000	0.88800	0.88800	0.88200	0.87000	0.87000	0.86400	0.75400	0.72200	0.69800	0.67000	0.66800
21.00000	0.93000	0.81000	0.85000	0.85000	0.85000	0.85000	0.71500	0.68000	0.66400	0.64000	0.64100
39.00000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000
49.00000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000
139.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
147.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000	-1.00000
161.00000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000
172.00000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000	-0.78000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 51. Continued.

SUPER 540 EXT*DSUPER 540 EXT*D CD TABLE

ALPHA/MACH	[illegible]	0.30000	0.50000	0.60000	0.65000	0.70000	0.75000	0.80000	0.85000	0.90000	1.00000
-180.0000	0.02200	0.02200	0.02200	0.02200	0.02220	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200
-175.0000	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200
-170.0000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
-160.0000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
-150.0000	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
-140.0000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
[illegible]	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
-110.0000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
-100.0000	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
[illegible]	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
-80.00000	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
-70.00000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
-60.00000	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
[illegible]	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
[illegible]	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000
[illegible]	0.54300	0.54000	0.56300	0.57800	0.57800	0.58100	0.58100	0.58100	0.58100	0.58100	0.58100
[illegible]	[illegible]	0.48000	0.52200	0.54500	0.54500	0.54700	0.55800	0.55800	0.55800	0.55800	0.55800
[illegible]	[illegible]	0.42000	0.46900	0.50600	0.50200	0.51200	0.52600	0.52600	0.52600	0.52600	0.52600
[illegible]	0.35800	0.35600	0.40900	0.44800	0.46100	0.47200	0.48900	0.49100	0.49100	0.49100	0.49100
[illegible]	0.29900	0.29900	0.33100	0.39600	0.41400	0.43100	0.45100	0.45300	0.45300	0.45300	0.45300
[illegible]	[illegible]	[illegible]	[illegible]	0.34500	0.37000	0.38600	0.40700	0.41400	0.41900	0.41900	0.41900
[illegible]	0.19100	0.19100	0.25300	0.30000	0.32600	0.34100	0.35800	0.36700	0.38100	0.38900	0.38900
[illegible]	0.16700	0.16700	0.23200	0.27500	0.30300	0.31800	0.33300	0.34200	0.36500	0.37200	0.37200
-13.00000	0.13500	0.13500	0.20200	0.24400	0.27100	0.28300	0.29900	0.30900	0.33900	0.35000	0.35100
-12.00000	0.10050	0.10050	0.17500	0.22000	0.24900	0.26100	0.27400	0.28500	0.32100	0.33500	0.33600
-11.00000	0.04600	0.04600	0.14200	0.18800	0.22600	0.23800	0.25100	0.26100	0.30200	0.31900	0.32100
-10.00000	[illegible]	0.02600	0.11600	0.15400	0.19500	0.21200	0.22900	0.24000	0.28700	0.30200	0.36500
-9.00000	0.01750	0.01750	0.07900	0.12700	0.16400	0.18800	0.20400	0.21800	0.26900	0.28700	0.29100
-8.00000	[illegible]	0.01250	0.04900	0.09600	0.13300	0.16200	0.18000	0.19500	0.25000	0.26900	0.27300
-7.00000	[illegible]	0.01020	0.02740	0.06000	0.10200	0.13200	0.15500	0.17100	0.23000	0.25000	0.25700
-6.00000	[illegible]	0.00920	0.01140	0.03900	0.07100	0.10200	0.12700	0.14600	0.21000	0.23000	0.23900
[illegible]	[illegible]	0.00850	0.01100	0.02230	0.04150	0.07150	0.09850	0.12000	0.16700	0.21100	0.22000
-4.00000	[illegible]	0.00800	0.00920	0.01340	0.02100	0.04300	0.07000	0.10000	0.16600	0.19000	0.19800
-3.00000	0.00790	0.00790	0.00860	0.00890	0.01260	0.02600	0.04500	0.07000	0.14100	0.16600	0.17600
-2.00000	0.00740	0.00740	0.00780	0.00760	0.00930	0.01650	0.02700	0.04200	0.11000	0.14000	0.15000
-1.00000	0.00710	0.00710	0.00710	0.00700	0.00730	0.00690	0.01650	0.02650	0.07000	0.10500	0.12000
[illegible]	[illegible]	0.00640	0.00680	0.00670	0.00650	0.00720	0.00890	0.01660	0.05000	0.07200	0.09500
[illegible]	[illegible]	0.00680	0.00670	0.00660	0.00650	0.00680	0.00740	0.01500	0.04500	0.06900	0.09300
[illegible]	[illegible]	[illegible]	0.00680	0.00670	0.00650	0.00720	0.00890	0.01680	0.05000	0.07200	0.09500
1.00000	[illegible]	0.00710	0.00710	0.00700	0.00730	0.00980	0.01650	0.02650	0.07000	0.10500	0.12600
2.00000	[illegible]	0.00740	0.00780	0.00760	0.00930	0.01650	0.02700	0.04200	0.11000	0.14000	0.15000
3.00000	0.00790	0.00790	0.00800	0.00890	0.01280	0.02600	0.04500	0.07000	0.14100	0.16600	0.17600
4.00000	[illegible]	0.00800	0.00920	0.01340	0.02200	0.04300	0.07000	0.10000	0.16600	0.19000	0.19800
[illegible]	[illegible]	0.00850	0.01100	0.02230	0.04150	0.07150	0.09850	0.12000	0.18700	0.21100	0.22000
6.00000	0.00920	0.00920	0.01240	0.03400	0.07100	0.10200	0.12700	0.14600	0.21000	0.23000	0.23900
7.00000	0.01020	0.01020	0.02740	0.06000	0.10200	0.13200	0.15500	0.17100	0.23000	0.25000	0.25700
8.00000	0.01250	0.01250	0.04900	0.09600	0.13300	0.16200	0.18000	0.19500	0.25300	0.26900	0.27300
[illegible]	0.01750	0.01750	0.07600	0.12700	0.16400	0.18800	0.20400	0.21800	0.26900	0.28700	0.29100
10.00000	[illegible]	0.02600	0.11000	0.15800	0.19500	0.21200	0.22900	0.24000	0.28700	0.30200	0.31500
11.00000	0.04600	0.04600	0.14200	0.18800	0.22600	0.23800	0.25100	0.26100	0.30200	0.31900	0.32100
12.00000	0.10050	0.10050	0.17500	0.22000	0.24900	0.26100	0.27400	0.28500	0.32100	0.33500	0.33600
13.00000	0.13500	0.13500	0.20200	0.24400	0.27100	0.28300	0.29900	0.30900	0.33900	0.35000	0.35100
[illegible]	0.16700	0.16700	0.23200	0.27500	0.30300	0.31800	0.33300	0.34200	0.36500	0.37200	0.37200
[illegible]	0.19100	0.19100	0.25300	0.30000	0.32600	0.34100	0.35800	0.36700	0.38100	0.38900	0.38900
[illegible]	0.24000	0.24000	0.30600	0.34500	0.37000	0.38600	0.40700	0.41400	0.41900	0.41900	0.41900
[illegible]	0.29900	0.29900	0.35100	0.39600	0.41400	0.43100	0.45100	0.45300	0.45300	0.45300	0.45300
[illegible]	0.35800	0.35800	0.40900	0.44800	0.46100	0.47200	0.48900	0.49100	0.49100	0.49100	0.49100
[illegible]	0.42000	0.42000	0.46900	0.50600	0.50200	0.51200	0.52600	0.52600	0.52600	0.52600	0.52600
[illegible]	0.46000	0.46000	0.52200	0.54500	0.54500	0.54700	0.55800	0.55800	0.55800	0.55800	0.55800
[illegible]	[illegible]	0.54000	0.56300	0.57800	0.57800	0.58100	0.58100	0.58100	0.58100	0.58100	0.58100
[illegible]	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000	0.60000
[illegible]	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200	1.39200
[illegible]	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200	1.66200
70.00000	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200	1.84200
[illegible]	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200	1.96200
[illegible]	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
100.0000	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200	2.00200
110.0000	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200	1.85200
130.0000	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200	1.65200
140.0000	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200	1.04200
[illegible]	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200	0.30200
160.0000	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200	0.24200
170.0000	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200	0.13200
175.0000	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200	0.06200
180.0000	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200	0.02200

Figure 51. Continued.

SUPER 540 EXT*DSUPER 540 EXT*D CM TABLE

ALPHA/MACH	[illegible]	0.20000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.90000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-170.00000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000	0.40000
-165.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-160.00000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000	0.30000
-135.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-90.00000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
-30.00000	0.17400	0.18400	0.19600	0.21400	0.23500	0.25000	0.26400	0.27700	0.29800
-23.00000	0.11200	0.11600	0.12800	0.14400	0.15700	0.17100	0.18300	0.20600	0.23200
-16.00000	0.07300	0.07800	0.08600	0.09700	0.10800	0.11700	0.13700	0.17600	0.20000
-15.00000	0.03400	0.06500	0.07300	0.08400	0.09700	0.11100	0.13300	0.17300	0.19500
-14.00000	0.0	0.02700	0.05400	0.06800	0.08600	0.10300	0.12700	0.16700	0.18900
-13.00000	0.0	0.00150	0.02500	0.05000	0.07400	0.09300	0.12200	0.16300	0.18400
-12.00000	0.0	0.0	0.00200	0.03000	0.06000	0.08300	0.11600	0.15700	0.17600
-11.00000	0.0	0.0	-0.00300	0.01400	0.04600	0.07400	0.10600	0.14900	0.17000
-10.00000	0.0	0.0	-0.00200	0.00200	0.03200	0.06500	0.10000	0.14200	0.16300
-9.00000	0.0	0.0	0.0	-0.00300	0.01600	0.05400	0.08900	0.13200	0.15400
-8.00000	0.0	0.0	0.0	-0.00400	0.00500	0.04100	0.08200	0.12300	0.14500
-7.00000	0.0	0.0	0.0	0.0	-0.00400	0.02750	0.07200	0.11250	0.13600
-6.00000	0.0	0.0	0.0	0.0	-0.00300	0.01600	0.06200	0.10000	0.12500
-4.00000	0.0	0.0	0.0	0.0	0.0	0.00500	0.04000	0.07600	0.10200
-3.00000	0.0	0.0	0.0	0.0	0.0	-0.00300	0.02600	0.06650	0.08700
-2.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.01300	0.05300	0.07000
-1.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.00350	0.03300	0.04500
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.00400	-0.03300	-0.04500
2.00000	0.0	0.0	0.0	0.0	0.0	0.0	-0.01300	-0.05300	-0.07000
3.00000	0.0	0.0	0.0	0.0	0.0	0.00250	-0.02600	-0.06700	-0.08700
4.00000	0.0	0.0	0.0	0.0	0.0	-0.00500	-0.04000	-0.07600	-0.10200
6.00000	0.0	0.0	0.0	0.0	0.00300	-0.01600	-0.06300	-0.10000	-0.12500
7.00000	0.0	0.0	0.0	0.0	0.00400	-0.02800	-0.07200	-0.11300	-0.13600
8.00000	0.0	0.0	0.0	0.00400	-0.00500	-0.04100	-0.08200	-0.12300	-0.14500
9.00000	0.0	0.0	0.0	0.00300	-0.01600	-0.05400	-0.08900	-0.13200	-0.15400
10.00000	0.0	0.0	0.00150	-0.00200	-0.03200	-0.06500	-0.10000	-0.14200	-0.16300
11.00000	0.0	0.0	0.00300	-0.01400	-0.04600	-0.07400	-0.10800	-0.14900	-0.17000
12.00000	0.0	0.0	-0.00200	-0.03000	-0.06000	-0.08300	-0.11600	-0.15700	-0.17600
13.00000	0.0	-0.00200	-0.02500	-0.05000	-0.07400	-0.09300	-0.12200	-0.16300	-0.18400
14.00000	0.0	-0.02700	-0.05400	-0.06800	-0.08600	-0.10300	-0.12700	-0.16700	-0.18900
15.00000	-0.03400	-0.06500	-0.07300	-0.08400	-0.09700	-0.11100	-0.13300	-0.17300	-0.19500
16.00000	-0.07300	-0.07800	-0.08600	-0.09700	-0.10800	-0.11700	-0.13700	-0.17600	-0.20000
23.00000	-0.11200	-0.11600	-0.12800	-0.14400	-0.15700	-0.17100	-0.18300	-0.20600	-0.23200
30.00000	-0.17400	-0.18400	-0.19600	-0.21400	-0.23500	-0.25000	-0.26400	-0.27700	-0.29800
90.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
135.00000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000	-0.50000
160.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
165.00000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000	-0.30000
170.00000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000	-0.40000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 51. Continued.

NACA 0015 CL TABLE

ALPHA/MACH	0.0	0.20000	0.40000	0.50000	0.60000	0.80000	1.00000
-180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-170.00000	0.80000	0.80000	0.80000	0.80000	0.80000	0.80000	0.80000
-160.00000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000	0.62000
-150.00000	0.80000	0.80000	0.80000	0.80000	0.80000	0.80000	0.80000
-130.00000	0.80000	0.80000	0.80000	0.80000	0.80000	0.80000	0.80000
-50.00000	-0.98000	-0.98000	-0.98000	-0.98000	-0.98000	-0.98000	-0.98000
-30.00000	-0.87000	-0.87000	-0.87000	-0.87000	-0.87000	-0.87000	-0.87000
-20.00000	-0.90000	-0.90000	-0.90000	-0.90000	-0.90000	-0.90000	-0.90000
-17.00000	-1.44000	-1.44000	-1.25000	-0.97500	-0.88200	-0.78000	-0.53000
-16.00000	-1.47000	-1.47000	-1.27000	-1.00000	-0.88000	-0.74000	-0.41000
-15.00000	-1.48000	-1.48000	-1.29000	-1.03000	-0.88000	-0.70000	-0.29000
-14.00000	-1.45000	-1.45000	-1.30000	-1.09000	-0.93500	-0.74000	-0.29000
-13.00000	-1.35000	-1.35000	-1.29000	-1.14000	-0.96000	-0.75000	-0.28500
-12.00000	-1.25000	-1.25000	-1.25000	-1.15000	-0.98000	-0.71000	-0.27500
-11.00000	-1.15000	-1.15000	-1.16000	-1.15000	-1.01000	-0.68000	-0.26500
-10.00000	-1.05000	-1.05000	-1.07000	-1.10000	-1.01000	-0.64500	-0.24000
-9.00000	-0.94500	-0.94500	-0.97000	-1.04000	-1.01000	-0.61000	-0.21500
-8.00000	-0.84000	-0.84000	-0.87000	-0.92000	-0.96000	-0.55500	-0.19000
-7.00000	-0.73500	-0.73500	-0.76300	-0.81500	-0.91000	-0.50000	-0.16500
-6.00000	-0.63000	-0.63000	-0.65500	-0.71000	-0.77000	-0.43000	-0.14000
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.00000	0.63000	0.63000	0.65500	0.71000	0.77000	0.43000	0.14000
7.00000	0.73500	0.73500	0.76300	0.81500	0.91000	0.50000	0.16500
8.00000	0.84000	0.84000	0.87000	0.92000	0.96000	0.55500	0.19000
9.00000	0.94500	0.94500	0.97000	1.04000	1.01000	0.61000	0.21500
10.00000	1.05000	1.05000	1.07000	1.10000	1.01000	0.64500	0.24000
11.00000	1.15000	1.15000	1.16000	1.15000	1.01000	0.68000	0.26500
12.00000	1.25000	1.25000	1.25000	1.15000	0.98000	0.71000	0.27500
13.00000	1.35000	1.35000	1.29000	1.14000	0.96000	0.75000	0.28500
14.00000	1.45000	1.45000	1.30000	1.09000	0.93500	0.74000	0.29000
15.00000	1.48000	1.48000	1.29000	1.03000	0.88000	0.70000	0.29000
16.00000	1.47000	1.47000	1.27000	1.00000	0.88000	0.74000	0.41000
17.00000	1.44000	1.44000	1.25000	0.97500	0.88200	0.78000	0.53000
20.00000	0.90000	0.90000	0.90000	0.90000	0.90000	0.90000	0.90000
30.00000	0.87000	0.87000	0.87000	0.87000	0.87000	0.87000	0.87000
50.00000	0.98000	0.98000	0.98000	0.98000	0.98000	0.98000	0.98000
130.00000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000
150.00000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000
160.00000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000	-0.62000
170.00000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000	-0.80000
180.00000	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 51. Continued.

NACA 0015 CD TABLE

ALPHA/MACH	0.0	0.20000	0.30000	0.40000	0.50000	0.60000	0.70000	0.75000	0.80000	0.85000	0.90000	1.00000
-180.00000	0.03430	0.03430	0.03430	0.03430	0.03430	0.03430	0.03430	0.03630	0.05560	0.09060	0.12600	0.12600
-179.00000	0.03450	0.03450	0.03450	0.03450	0.03450	0.03450	0.03560	0.04430	0.07060	0.10800	0.14300	0.14300
-178.00000	0.03480	0.03480	0.03480	0.03480	0.03480	0.03480	0.03770	0.05360	0.09660	0.12600	0.16000	0.16000
-177.00000	0.03510	0.03510	0.03510	0.03510	0.03510	0.03510	0.04110	0.06410	0.10800	0.14300	0.17700	0.17700
-176.00000	0.03560	0.03560	0.03560	0.03560	0.03560	0.03600	0.04860	0.07460	0.12600	0.16100	0.19300	0.19300
-175.00000	0.03650	0.03650	0.03650	0.03650	0.03650	0.03800	0.06180	0.09560	0.14600	0.17900	0.21000	0.21000
-174.00000	0.03760	0.03760	0.03760	0.03760	0.03770	0.04130	0.08260	0.11700	0.16400	0.19600	0.22600	0.22600
-173.00000	0.03880	0.03880	0.03880	0.03880	0.04000	0.04970	0.10600	0.13800	0.18300	0.21400	0.24300	0.24300
-172.00000	0.04010	0.04010	0.04010	0.04010	0.04260	0.06560	0.12800	0.15900	0.20200	0.23200	0.26000	0.26000
-171.00000	0.04160	0.04160	0.04160	0.04190	0.04960	0.09160	0.15100	0.17900	0.22100	0.24900	0.27600	0.27600
-170.00000	0.04360	0.04360	0.04360	0.04980	0.07560	0.11600	0.17300	0.20600	0.24100	0.26700	0.29300	0.29300
-169.00000	0.04810	0.04880	0.04960	0.06460	0.10400	0.14300	0.19500	0.22100	0.25800	0.28500	0.31000	0.31000
-168.00000	0.05310	0.05380	0.06610	0.08310	0.13300	0.17600	0.21600	0.24100	0.27700	0.30300	0.32600	0.32600
-167.00000	0.05900	0.06080	0.06480	0.10500	0.16100	0.19400	0.23900	0.26200	0.29600	0.32100	0.34300	0.34300
-166.00000	0.08060	0.08740	0.09610	0.13300	0.19000	0.22000	0.26100	0.28300	0.31400	0.33600	0.36000	0.36000
-165.00000	0.11500	0.12000	0.13200	0.16600	0.21900	0.24500	0.28300	0.30400	0.33300	0.35600	0.37600	0.37600
-164.00000	0.14600	0.15600	0.16900	0.20100	0.24600	0.27100	0.30600	0.32500	0.35200	0.37400	0.39300	0.39300
-160.00000	0.32600	0.33000	0.33600	0.34800	0.36000	0.37300	0.39400	0.40600	0.42600	0.44200	0.45800	0.45800
-130.00000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000
-90.00000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000
-50.00000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000
-20.00000	0.30000	0.30400	0.31000	0.32200	0.33400	0.34700	0.36800	0.38000	0.40000	0.41600	0.43200	0.43200
-18.00000	0.12600	0.13800	0.14900	0.18000	0.25900	0.27900	0.30900	0.32600	0.35100	0.38200	0.40000	0.40000
-17.00000	0.09510	0.10300	0.11200	0.14500	0.22200	0.24600	0.28000	0.29900	0.32600	0.36500	0.38300	0.38300
-16.00000	0.06060	0.06740	0.07610	0.11200	0.19500	0.22000	0.25700	0.27800	0.30700	0.34800	0.36700	0.36700
-15.00000	0.04970	0.05130	0.05600	0.06800	0.16600	0.19500	0.23500	0.25700	0.28600	0.33000	0.35000	0.35000
-14.00000	0.04130	0.04220	0.04530	0.06200	0.13700	0.16900	0.21300	0.23600	0.27000	0.31200	0.33400	0.33400
-13.00000	0.03490	0.03580	0.03680	0.04350	0.10900	0.14500	0.19000	0.21500	0.25100	0.29500	0.31700	0.31700
-12.00000	0.02900	0.02900	0.02900	0.03600	0.07920	0.11800	0.16900	0.19500	0.23200	0.27700	0.30000	0.30000
-11.00000	0.02600	0.02600	0.02600	0.02630	0.05160	0.09270	0.14700	0.17400	0.21500	0.25900	0.28400	0.28400
-10.00000	0.02340	0.02340	0.02340	0.02340	0.03280	0.06670	0.12500	0.15300	0.19500	0.24100	0.26700	0.26700
-9.00000	0.02080	0.02080	0.02080	0.02080	0.02400	0.04370	0.10200	0.13300	0.17600	0.22300	0.25000	0.25000
-8.00000	0.01890	0.01890	0.01890	0.01890	0.02000	0.03200	0.08020	0.11200	0.15700	0.20600	0.23400	0.23400
-7.00000	0.01720	0.01720	0.01720	0.01720	0.01720	0.02110	0.05220	0.09100	0.13800	0.18800	0.21700	0.21700
-6.00000	0.01560	0.01560	0.01560	0.01560	0.01560	0.01690	0.03640	0.07000	0.12000	0.17000	0.20000	0.20000
-5.00000	0.01410	0.01410	0.01410	0.01410	0.01410	0.01410	0.03010	0.04900	0.10000	0.15300	0.18400	0.18400
-4.00000	0.01300	0.01300	0.01300	0.01300	0.01300	0.01300	0.02040	0.04270	0.08250	0.13500	0.16700	0.16700
-3.00000	0.01230	0.01230	0.01230	0.01230	0.01230	0.01230	0.01590	0.03640	0.06500	0.11700	0.15100	0.15100
-2.00000	0.01200	0.01200	0.01200	0.01200	0.01200	0.01200	0.01320	0.02430	0.04500	0.10000	0.13400	0.13400
-1.00000	0.01150	0.01150	0.01150	0.01150	0.01150	0.01150	0.01150	0.01500	0.03900	0.08250	0.11700	0.11700
0.0	0.01130	0.01130	0.01130	0.01130	0.01130	0.01130	0.01130	0.01250	0.03300	0.06500	0.10000	0.10000
1.00000	0.01150	0.01150	0.01150	0.01150	0.01150	0.01150	0.01150	0.01500	0.03900	0.08250	0.11700	0.11700

Figure 51. Continued.

[illegible]	0.01200	0.01200	0.01200	0.01200	0.01200	0.01200	0.01320	0.02430	0.04500	0.10000	0.13400	0.13400
[illegible]	0.01230	0.01230	0.01230	0.01230	0.01230	0.01230	0.01590	0.03640	0.06500	0.11700	0.15100	0.15100
4.00000	0.01300	0.01300	0.01300	0.01300	0.01300	0.01300	0.02040	0.04270	0.08250	0.13500	0.16700	0.16700
[illegible]	0.01410	0.01410	0.01410	0.01410	0.01410	0.01410	0.03010	0.04960	0.10000	0.15300	0.18400	0.18400
[illegible]	0.01500	0.01500	0.01500	0.01500	0.01500	0.01690	0.03640	0.07000	0.12000	0.17000	0.20000	0.20000
7.00000	0.01720	0.01720	0.01720	0.01720	0.01720	0.02110	0.05220	0.09100	0.13800	0.18600	0.21700	0.21700
[illegible]	0.01890	0.01890	0.01890	0.01890	0.02200	0.03200	0.08020	0.11200	0.15700	0.20600	0.23400	0.23400
[illegible]	[illegible]	[illegible]	0.02080	0.02080	0.02400	0.04070	0.10200	0.13300	0.17600	0.22300	0.25000	0.25000
10.[illegible]	0.02340	0.02340	0.02340	0.02340	0.03280	0.06070	0.12500	0.15300	0.19500	0.24100	0.26700	0.26700
11.[illegible]	0.02600	0.02600	0.02600	0.02630	0.05100	0.09270	0.14700	0.17400	0.21500	0.25900	0.28400	0.28400
12.00000	0.02900	0.02900	0.02900	0.03600	0.07920	0.11600	0.16900	0.19500	0.23200	0.27700	0.30000	0.30000
[illegible]	0.03490	0.03580	0.03680	0.04350	0.10900	0.14500	0.19000	0.21500	0.25100	0.29500	0.31700	0.31700
14.00000	0.04130	0.04220	0.04530	0.06260	0.13700	0.16900	0.21300	0.23600	0.27000	0.31200	0.33400	0.33400
15.00000	0.04470	0.05130	0.05660	0.08400	0.16600	0.19500	0.23500	0.25700	0.28800	0.33000	0.35000	0.35000
16.[illegible]	[illegible]	0.06740	0.07910	0.11200	0.19500	0.22000	0.25700	0.27800	0.30700	0.34800	0.36700	0.36700
17.[illegible]	[illegible]	0.10000	0.11200	0.14500	0.22200	0.24600	0.28600	0.29900	0.32600	0.36500	0.38300	0.38300
18.[illegible]	0.12600	0.13800	0.14900	0.18000	0.25900	0.27900	0.30900	0.32600	0.35100	0.38200	0.40000	0.40000
[illegible]	[illegible]	[illegible]	0.31000	0.32200	0.33400	0.34700	0.36800	0.38000	0.40000	0.41600	0.43200	0.43200
[illegible]	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000	1.15000
[illegible]	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000	1.77000
[illegible]	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000	1.25000
[illegible]	0.32600	0.33000	0.33600	0.34800	0.36000	0.37330	0.39400	0.40600	0.42600	0.44200	0.45800	0.45800
164.00000	0.14600	0.15800	0.16900	0.20100	0.24600	0.27100	0.30600	0.32500	0.35200	0.37400	0.39300	0.39300
165.00000	0.11500	0.12000	0.13200	0.16000	0.21900	0.24500	0.28300	0.30400	0.33300	0.35600	0.37600	0.37600
166.[illegible]	[illegible]	[illegible]	0.09810	0.13300	0.19000	0.22000	0.26100	0.28300	0.31400	0.33800	0.36000	0.36000
167.[illegible]	0.05960	[illegible]	0.06480	0.10500	0.16100	0.19400	0.23900	0.26200	0.29600	0.32100	0.34360	0.34300
[illegible]	[illegible]	[illegible]	0.05610	0.06310	0.13300	0.17000	0.21600	0.24100	0.27700	0.30300	0.32600	0.32600
[illegible]	0.04810	0.04880	0.04960	0.06460	0.10400	0.14300	0.19500	0.22100	0.25800	0.28500	0.31000	0.31000
[illegible]	0.04360	0.04360	0.04360	0.04980	0.07560	0.11800	0.17300	0.20000	0.24000	0.26700	0.29300	0.29300
171.00000	0.04160	0.04160	0.04160	0.04190	0.04960	0.09160	0.15100	0.17900	0.22100	0.24900	0.27600	0.27600
172.00000	0.04010	0.04010	0.04010	0.04010	0.04280	0.06560	0.12800	0.15900	0.20200	0.23200	0.26000	0.26000
173.[illegible]	0.03880	0.03880	0.03880	0.03880	0.04000	0.04970	0.16600	0.13800	0.18300	0.21400	0.24300	0.24300
174.[illegible]	0.03760	0.03760	0.03760	0.03760	0.03770	0.04130	0.08260	0.11700	0.16400	0.19600	0.22600	0.22600
175.[illegible]	0.03650	0.03650	0.03650	0.03650	0.03650	0.03800	0.06180	0.09560	0.14600	0.17900	0.21000	0.21000
176.[illegible]	0.03560	0.03560	0.03560	0.03560	0.03560	0.03600	0.04860	0.07460	0.12600	0.16100	0.19300	0.19300
177.[illegible]	0.03510	0.03510	0.03510	0.03510	0.03510	0.03510	0.04110	0.06410	0.10800	0.14300	0.17700	0.17700
178.[illegible]	0.03480	0.03480	0.03480	0.03480	0.03480	0.03480	0.03770	0.05360	0.09000	0.12600	0.16000	0.16000
179.00000	0.03450	0.03450	0.03450	0.03450	0.03450	0.03450	0.03560	0.04430	0.07000	0.10800	0.14300	0.14300
[illegible]	0.03430	0.03430	0.03430	0.03430	0.03430	0.03430	0.03430	0.03630	0.05560	0.09000	0.12600	0.12600

Figure 51. Continued

NACA 001[illegible] CM TABLE

ALPHA/MACH	0.0	1.00000
-180.0[illegible]	0.0	0.0
180.0000	0.0	0.0

Figure 51. Concluded.

are input. The data for each of these basic groups are printed whether the group is input on cards or called from the data library. If a group is called from library and altered by an &CHANGE card, the &CHANGE card is listed and the group is updated with the specified changes. However, during parameter sweeps (NPART = 10), the inputs in the groups are changed, and the &CHANGE card is not printed out. The user should refer to the Data Deck Listing to verify which inputs were changed in such sweeps.

6.3.4 Elastic Blade Data (Figure 52)

If elastic blade data blocks are input, the sets of data within each block are printed in the order of input with the Rotor 1 block followed by the Rotor 2 block. The printout of the weight, beamwise and chordwise inertias, and center of gravity offsets is followed by the total weight, tip weight, and flapping inertia of each blade.

The modal displacements and bending moment coefficients for each mode are printed as input, from root to tip, in the Rotor Shaft Reference System for that rotor (see section 6.1.5).

The remaining constants input for each mode (mode type, generalized inertia, damping ratio, etc.) are printed immediately following the mode shapes.

6.3.5 Check of Aerodynamic Inputs

Several of the inputs to the Rotor Airfoil Aerodynamic Subgroups and the Wing and Stabilizing Surface Aerodynamic Groups are changed if their input values do not satisfy certain criteria or are obviously unreasonable. An error message is printed, after the printout of any aeroelastic blade data, explaining the action taken. The changing of any of these values will not in itself terminate execution.

6.3.6 Trim Condition in Accelerated Flight

If the rotorcraft is to be trimmed in accelerated flight, i.e., a coordinated turn, a pullup, or pushover, information is printed concerning these conditions following any correction to aerodynamic inputs. No message is printed for an unaccelerated flight condition.

MAIN ROTOR AEROELASTIC BLADE DISTRIBUTIONS AND DATA

BLADE NUMBER	STATION RADIUS(IN)	WEIGHT (LB/IN)	BEAMWISE INERTIA (IN-LB-SEC**2/IN)	CHORDWISE INERTIA (IN-LB-SEC**2/IN)	BEAMWISE CG OFFSET (IN)	CHORDWISE CG OFFSET (IN)
1	6.00	5.3702	0.0001	0.0690	0.0	0.0
2	20.57	5.7136	0.0590	0.1149	0.0	0.053
3	37.50	6.1672	0.0898	0.1190	0.0	3.610
4	52.80	4.8217	0.0131	0.2264	0.0	1.529
5	66.00	0.9526	0.0024	0.1183	0.0	0.900
6	81.50	0.7750	0.0017	0.1189	0.0	1.390
7	92.40	0.8580	0.0017	0.1469	0.0	1.776
8	103.00	0.8360	0.0017	0.1453	0.0	1.710
9	118.80	0.8690	0.0018	0.1553	0.0	2.385
10	132.00	0.7626	0.0014	0.1357	0.0	1.450
11	145.20	0.7260	0.0013	0.1305	0.0	1.340
12	155.80	0.8750	0.0014	0.1280	0.0	0.850
13	171.60	1.0980	0.0024	0.1460	0.0	0.571
14	184.80	1.0620	0.0024	0.1290	0.0	-0.550
15	198.00	1.0390	0.0014	0.1159	0.0	0.010
16	212.30	1.2600	0.0012	0.1255	0.0	-1.017
17	224.40	1.1860	0.0013	0.1045	0.0	-1.876
18	238.10	1.2660	0.0015	0.1226	0.0	-1.129
19	250.80	1.1890	0.0018	0.1161	0.0	-1.970
20	264.00	1.1600	0.0027	0.1399	0.0	-0.430

TOTAL BLADE WEIGHT = 488.19 LB   BLADE TIP WEIGHT = 0.0 LB   FLAPPING INERTIA/BLADE = 1503.4 SLUG-FT**2

Figure 52. Elastic Blade Data and Rotor-Induced Velocity Distribution Table.

MAIN ROTOR

MODE 1

BLADE NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	-0.0000	0.0002	-0.1117	0.0	-84.6	10.5
1	6.00	0.0027	0.0002	-0.0992	10.6	-82.6	-18.5
2	20.57	0.0781	0.0002	-0.0452	10.7	-76.0	-120.2
3	37.50	0.1424	0.0001	-0.1012	18.6	-70.0	-78.4
4	52.80	0.2004	0.0001	-0.1336	35.0	-63.7	-35.6
5	66.00	0.2565	0.0000	-0.1644	48.6	-57.0	-14.3
6	81.50	0.3093	-0.0000	-0.2053	62.6	-50.4	-7.8
7	92.40	0.3506	-0.0001	-0.2379	76.9	-45.5	6.2
8	103.00	0.3967	-0.0002	-0.2720	76.2	-41.3	27.3
9	118.80	0.4505	-0.0003	-0.3226	76.5	-36.0	63.6
10	132.00	0.5003	-0.0003	-0.3663	77.7	-31.9	104.6
11	145.20	0.5562	-0.0004	-0.4121	72.3	-28.5	137.4
12	155.80	0.5962	-0.0005	-0.4454	66.3	-26.2	165.4
13	171.60	0.6498	-0.0006	-0.4843	57.5	-23.1	199.1
14	184.80	0.6997	-0.0007	-0.5103	51.2	-20.1	216.7
15	198.00	0.7496	-0.0008	-0.5292	47.6	-17.0	223.9
16	212.30	0.8037	-0.0009	-0.5416	40.3	-13.5	218.5
17	224.40	0.8495	-0.0010	-0.5478	33.5	-10.0	174.3
18	238.10	0.9015	-0.0011	-0.5505	24.0	-6.4	123.1
19	250.80	0.9498	-0.0011	-0.5506	12.5	-3.0	60.4
20	264.00	1.0000	-0.0012	-0.5507	2.4	-0.6	9.7

MODE 2

BLADE NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	-0.1987	0.0009	0.0	118480.0	3.0
1	6.00	-0.0155	-0.1983	-0.0066	-1331.0	115642.0	26.0
2	20.57	-0.0682	-0.1921	2.7590	-4255.0	107964.0	1127.0
3	37.50	-0.1132	-0.1651	3.0442	-7167.0	97654.0	721.0
4	52.80	-0.1466	-0.1196	3.1790	-9922.0	88256.0	534.0
5	66.00	-0.1649	-0.0738	3.2661	-11555.0	79730.0	455.0
6	81.50	-0.1683	-0.0118	3.3564	-11833.0	70298.0	428.0
7	92.40	-0.1617	0.0364	3.4179	-11297.0	63969.0	390.0
8	103.00	-0.1503	0.0860	3.4677	-10433.0	58063.0	358.0
9	118.80	-0.1274	0.1641	3.5194	-8883.0	49397.0	319.0
10	132.00	-0.1046	0.2325	3.5496	-7506.0	42478.0	288.0
11	145.20	-0.0795	0.3034	3.5691	-6116.0	35829.0	273.0
12	155.80	-0.0579	0.3614	3.5765	-5038.0	30703.0	263.0
13	171.60	-0.0247	0.4511	3.5824	-3628.0	23497.0	258.0
14	184.80	0.0039	0.5273	3.5817	-2643.0	17972.0	248.0
15	198.00	0.0328	0.6047	3.5796	-1835.0	12967.0	236.0
16	212.30	0.0645	0.6896	3.5804	-1160.0	8270.0	220.0
17	224.40	0.0914	0.7620	3.5821	-698.0	5019.0	179.0
18	238.10	0.1217	0.8443	3.5844	-343.0	2239.0	131.0
19	250.80	0.1493	0.9206	3.5801	-125.1	630.3	76.6
20	264.00	0.1776	1.0000	3.5812	-15.8	14.3	16.4

MODE 3

BLADE NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.2116	0.0044	0.0	-175567.0	267.0
1	6.00	-0.0011	0.2109	0.0270	-8809.0	-172326.0	267.0
2	20.57	-0.1266	0.2026	73.5222	30877.0	-162611.0	34301.0
3	37.50	-0.3065	0.1669	79.7210	35776.0	-149901.0	29179.0
4	52.80	-0.4537	0.1075	83.2022	29450.0	-138456.0	26511.0
5	66.00	-0.5672	0.0527	86.1894	22025.0	-127607.0	24384.0
6	81.50	-0.6718	-0.0127	89.8236	14900.0	-114613.0	23390.0
7	92.40	-0.7172	-0.0571	92.4823	10609.0	-105400.0	21940.0
8	103.00	-0.7340	-0.0977	95.1171	7740.0	-96290.0	20560.0
9	118.80	-0.7166	-0.1552	98.8338	4367.0	-82737.0	18666.0
10	132.00	-0.6632	-0.2001	102.0923	2131.0	-71591.0	16677.0
11	145.20	-0.5752	-0.2425	105.2356	1250.0	-60564.0	15111.0
12	155.80	-0.4788	-0.2745	107.6866	1150.0	-51912.0	13748.0
13	171.60	-0.3082	-0.3211	110.8172	644.0	-39763.0	12171.0
14	184.80	-0.1465	-0.3597	113.1275	-248.0	-30483.0	10456.0
15	198.00	0.0261	-0.3986	115.1347	-1582.0	-22145.0	9079.0
16	212.30	0.2226	-0.4411	116.9251	-3376.0	-14390.0	7621.0
17	224.40	0.3921	-0.4775	118.1693	-3335.0	-8856.0	6119.0
18	238.10	0.5784	-0.5198	119.2222	-3269.0	-4136.0	4550.0
19	250.80	0.7342	-0.5610	119.7944	-2071.0	-1284.0	2769.0
20	264.00	0.8860	-0.6055	120.0000	-444.0	-73.9	922.1

Figure 52. Continued.

STATION NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0419	-0.0115	0.0	-57626.0	-113.0
1	6.00	-0.0616	0.0417	-0.0531	4550.0	-57153.0	-18.0
2	20.67	-0.1564	0.0389	-14.0406	9659.0	-55643.0	-5566.0
3	37.50	-0.2414	0.0273	-15.5866	16924.0	-51193.0	-5580.0
4	52.80	-0.3215	0.0067	-16.2922	18850.0	-47080.0	-5667.0
5	66.00	-0.3841	-0.0117	-16.9015	17879.0	-43320.0	-5411.0
6	81.50	-0.4419	-0.0325	-17.6554	16792.0	-38797.0	-5230.0
7	92.40	-0.4721	-0.0463	-18.2368	16134.0	-35554.0	-5027.4
8	103.00	-0.4936	-0.0596	-18.8368	15369.0	-32395.0	-4844.0
9	118.80	-0.5000	-0.0762	-19.7575	14210.0	-27686.0	-4646.0
10	132.00	-0.4902	-0.0885	-20.6523	13261.0	-23770.0	-4398.0
11	145.20	-0.4694	-0.0984	-21.5933	12495.0	-19916.0	-4106.0
12	155.80	-0.4301	-0.1042	-22.3851	12263.0	-16677.0	-3806.0
13	171.00	-0.3371	-0.1088	-23.4731	11387.0	-12567.0	-3368.0
14	184.80	-0.2204	-0.1080	-24.3278	10587.0	-9330.0	-2762.0
15	198.00	-0.0645	-0.1040	-25.1013	9685.0	-6417.0	-2213.0
16	212.30	0.1050	-0.0962	-25.8065	8324.0	-3780.0	-1623.0
17	224.40	0.2920	-0.0866	-26.2839	6402.0	-2164.0	-1123.0
18	238.10	0.5217	-0.0730	-26.6846	3896.0	-864.0	-742.0
19	250.80	0.7522	-0.0590	-26.9601	1568.0	-167.0	-482.0
20	264.00	1.0000	-0.0437	-27.0797	105.4	6.5	-229.8

STATION NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	-0.0236	-0.2208	0.0	89348.0	175.0
1	6.00	0.1158	-0.0273	0.0733	-8936.0	88887.0	-4.0
2	20.67	0.2755	-0.0195	-1.9248	-49701.0	87177.0	-4536.0
3	37.50	0.3985	-0.0102	-2.2671	-74151.0	83913.0	2364.0
4	52.80	0.4757	0.0095	-1.6942	-66384.0	81304.0	5667.0
5	66.00	0.4899	0.0188	-0.9647	-50901.0	78374.0	6954.0
6	81.50	0.4269	0.0134	0.1293	-36891.0	73469.0	7317.0
7	92.40	0.3041	0.0016	1.0642	-29167.0	69289.0	7714.0
8	103.00	0.1703	-0.0141	2.1428	-22534.0	64859.0	7933.0
9	118.80	-0.0063	-0.0405	3.9515	-13304.0	57874.0	7987.0
10	132.00	-0.2652	-0.0613	5.7191	-6210.0	51810.0	7555.0
11	145.20	-0.4529	-0.0771	7.5055	846.0	45758.0	6943.0
12	155.80	-0.5761	-0.0834	8.8911	6571.0	40957.0	6235.0
13	171.00	-0.6696	-0.0794	10.6038	14180.0	33773.0	5346.0
14	184.80	-0.6985	-0.0611	11.7716	18473.0	27684.0	4593.0
15	198.00	-0.6120	-0.0281	12.6917	20770.0	21642.0	4151.0
16	212.30	-0.4259	0.0291	13.4269	19836.0	15191.0	3844.0
17	224.40	-0.1471	0.0794	13.9573	16275.0	10065.0	3732.0
18	238.10	0.2160	0.1506	14.4036	9639.0	4986.0	3256.0
19	250.80	0.5927	0.2211	14.4716	3388.0	1590.0	2142.0
20	264.00	1.0000	0.2960	14.4257	-416.5	58.8	644.6

STATION NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0	-0.0327	6762.0	0.0	-23.0
1	6.00	0.0018	-0.0005	-0.0344	4030.0	-55.0	-26.0
2	20.67	0.0401	-0.0016	-1.7771	2564.0	-181.0	-100.0
3	37.50	0.1006	-0.0024	-1.8273	1925.0	-239.0	-70.0
4	52.80	0.1613	-0.0029	-1.8537	1418.0	-279.0	-34.0
5	66.00	0.2101	-0.0032	-1.8818	1059.4	-297.1	-14.3
6	81.50	0.2692	-0.0031	-1.9202	863.0	-266.0	-7.7
7	92.40	0.3115	-0.0028	-1.9510	699.6	-263.2	8.4
8	103.00	0.3529	-0.0026	-1.9839	620.3	-238.4	27.8
9	118.80	0.4149	-0.0021	-2.0330	520.4	-199.3	64.3
10	132.00	0.4669	-0.0013	-2.0786	463.9	-166.6	167.4
11	145.20	0.5189	-0.0014	-2.1228	398.7	-136.9	141.5
12	155.80	0.5667	-0.0012	-2.1571	348.5	-115.4	171.1
13	171.00	0.6234	-0.0005	-2.1962	285.6	-85.0	207.2
14	184.80	0.6702	-0.0000	-2.2263	245.4	-62.2	220.8
15	198.00	0.7295	0.0005	-2.2474	217.0	-41.6	235.3
16	212.30	0.7872	0.0011	-2.2619	193.0	-22.9	230.6
17	224.40	0.8360	0.0017	-2.2691	146.9	-12.4	184.5
18	238.10	0.8927	0.0023	-2.2726	101.6	-4.2	130.6
19	250.80	0.9451	0.0030	-2.2732	51.0	-0.5	64.0
20	264.00	1.0000	0.0037	-2.2731	8.6	0.1	10.1

Figure 52. Continued.

MODE 7

BLADE STATION NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	-0.0000	-0.0000	-0.1374	-8787.0	0.0	240.0
1	6.00	-0.0047	-0.0166	-0.1163	-13704.0	1913.0	248.0
2	20.57	-0.1817	-0.0573	63.6346	17066.0	6310.0	28746.0
3	37.50	-0.4024	-0.0994	69.2832	18879.0	6575.0	23847.0
4	52.80	-0.5810	-0.1321	72.1635	10624.0	7423.0	21324.0
5	66.00	-0.7092	-0.1543	74.5974	2413.0	5912.0	19488.0
6	81.50	-0.8106	-0.1696	77.5302	-3799.0	4790.0	18657.0
7	92.40	-0.8458	-0.1726	79.6600	-6554.0	4278.0	17445.0
8	103.00	-0.8494	-0.1692	81.7494	-7865.0	4007.0	16298.0
9	118.80	-0.8100	-0.1555	84.6567	-8489.0	3700.0	14744.0
10	132.00	-0.7376	-0.1366	87.1726	-8445.0	3454.0	13106.0
11	145.20	-0.6319	-0.1116	89.5764	-7236.0	3329.0	11860.0
12	155.80	-0.5226	-0.0874	91.4372	-5790.0	3251.0	10792.0
13	171.60	-0.3332	-0.0468	93.7962	-4189.0	2926.0	9576.0
14	184.80	-0.1557	-0.0096	95.5322	-3506.0	2474.0	8268.0
15	198.00	0.0237	0.0291	97.0350	-3435.0	1888.0	7224.0
16	212.30	0.2495	0.0729	98.3768	-3947.0	1150.0	6112.0
17	224.40	0.4307	0.1160	99.3129	-3331.0	687.0	4919.0
18	238.10	0.6455	0.1531	100.1068	-2898.0	209.0	3669.0
19	250.80	0.8258	0.1911	100.5295	-1754.0	-16.0	2218.0
20	264.00	1.0000	0.2295	100.6786	-376.4	-31.1	722.9

MODE [illegible]

BLADE STATION NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0	0.0000	-21027.0	0.0	9.0
1	6.00	-0.0146	-0.0062	-0.0030	-8200.0	760.0	17.0
2	20.57	-0.0600	-0.0212	-14.6321	-5885.0	2422.0	-8807.0
3	37.50	-0.1764	-0.0392	-17.0180	2139.0	4600.0	-6273.0
4	52.80	-0.2653	-0.0551	-18.0434	5893.0	4657.0	-8137.0
5	66.00	-0.3373	-0.0675	-18.9279	6777.0	4679.0	-7732.0
6	81.50	-0.4091	-0.0792	-20.0258	7663.0	4686.0	-7487.0
7	92.40	-0.4509	-0.0853	-20.8593	8272.0	4693.0	-7181.0
8	103.00	-0.4640	-0.0897	-21.7195	8659.0	4657.0	-6909.0
9	118.80	-0.5159	-0.0925	-23.0248	9034.0	4551.0	-6598.0
10	132.00	-0.5219	-0.0913	-24.2749	9273.0	4426.0	-6225.0
11	145.20	-0.5099	-0.0866	-25.5760	9598.0	4288.0	-5820.0
12	155.80	-0.4806	-0.0766	-26.6613	10006.0	4175.0	-5427.0
13	171.60	-0.3993	-0.0615	-28.1413	10396.0	3897.0	-4822.0
14	184.80	-0.2936	-0.0414	-29.2985	10326.0	3529.0	-4016.0
15	198.00	-0.1513	-0.0160	-30.3440	10009.0	3069.0	-3287.0
16	212.30	0.0439	0.0170	-31.2984	9054.0	2446.0	-2493.0
17	224.40	0.2386	0.0480	-31.9470	7172.0	1766.0	-1782.0
18	238.10	0.4851	0.0874	-32.4932	4487.0	987.0	-1269.0
19	250.80	0.7327	0.1254	-32.8631	1645.0	365.0	-766.0
20	264.00	1.0000	0.1659	-33.0216	126.5	25.5	-334.6

MODE [illegible]

BLADE STATION NUMBER	STATION RADIUS	DISPLACEMENT OUT-OF-PLANE	DISPLACEMENT INPLANE	DISPLACEMENT TORSIONAL	BENDING MOMENT COEFFICIENT OUT-OF-PLANE	BENDING MOMENT COEFFICIENT INPLANE	BENDING MOMENT COEFFICIENT TORSIONAL
0	0.0	0.0	0.0	0.0000	42432.0	0.0	-113.0
1	6.00	0.0096	0.0262	-0.0015	16085.0	-10114.0	-129.0
2	20.57	0.1806	0.0889	-5.6866	-20265.0	-33017.0	-101.0
3	37.50	0.3602	0.1495	-4.7647	-47203.0	-51037.0	7382.0
4	52.80	0.4925	0.1895	-3.4335	-41747.0	-54657.0	11288.0
5	66.00	0.5477	0.2065	-2.0164	-27565.0	-53023.0	13007.0
6	81.50	0.5019	0.2046	0.0115	-15615.0	-51181.0	13519.0
7	92.40	[illegible]	0.1859	1.7154	-9552.0	-49749.0	14098.0
8	103.00	0.2709	0.1594	3.6402	-4573.0	-47962.0	14443.0
9	118.80	0.0401	0.1062	6.6243	2344.0	-44289.0	14612.0
10	132.00	-0.1773	0.0660	9.9592	7583.0	-40388.0	14112.0
11	145.20	-0.3656	0.0113	13.1873	12657.0	-35868.0	13274.0
12	155.80	[illegible]	-0.0249	15.7657	17224.0	-31066.0	12241.0
13	171.60	-0.6693	-0.0701	19.0832	23023.0	-24838.0	10652.0
14	184.80	-0.6981	-0.0961	21.4807	25813.0	-19007.0	9417.0
15	198.00	-0.6266	-0.1096	23.4696	26575.0	-13417.0	8369.0
16	212.30	[illegible]	-0.1091	25.2059	23828.0	-8139.0	7395.0
17	224.40	-0.1071	-0.0963	26.4211	18881.0	-4594.0	6644.0
18	238.10	0.2020	-0.0782	27.4493	10738.0	-1865.0	5491.0
19	250.80	0.5855	-0.0549	27.8414	3624.0	-479.0	3558.0
20	264.00	1.0000	-0.0294	27.9108	-88.0	-29.0	1142.0

Figure 52. Continued.

MODE NUMBER	1	2	3	4	5	6
MODE TYPE	RIGID BODY	CYCLIC	CYCLIC	CYCLIC	CYCLIC	COLLECTIVE
NATURAL FREQUENCY,/REV	0.10000E+01	0.15994E+01	0.23579E+01	0.28561E+01	0.45021E+01	0.16434E+01
GENERALIZED INERTIA	0.31021E+01	0.25107E+01	0.13776E+02	0.22168E+01	0.26917E+01	0.28919E+01
DAMPING RATIO	0.0	0.20000E-01	0.40000E-01	0.23000E-01	0.21000E-01	0.20000E-01
COEF OF INPLANE SHEAR AT HUB,LB	-0.47800E+01	0.52517E+04	-0.55916E+04	-0.11085E+04	0.62458E+03	-0.16168E+02
COEF OF OUT-OF-PLANE SHEAR AT HUB,LB	0.57837E+04	-0.12968E+04	0.17334E+05	-0.24900E+05	0.47759E+05	0.58069E+04
COEF FOR PITCH LINK LOAD,LB	0.22340E+02	-0.13421E+04	-0.44840E+05	0.76262E+04	0.56574E+04	0.12100E+02
LEAD-LAG HINGE DISPLACEMENT,DEG	0.0	0.0	0.0	0.0	0.0	0.0
INTEGRAL OF OUT-OF-PLANE * R * DM	0.6[illegible]235E+02	0.82500E-01	-0.12861E+01	0.48180E+00	-0.12342E+01	0.65721E+02
INTEGRAL OF OUT-OF-PLANE * DM	0.[illegible]6431E+01	-0.82600E+00	-0.25932E+01	-0.21024E+01	0.21936E+01	0.46628E+01
INTEGRAL OF INPLANE * R * DM	-0.66100E-01	0.48725E+02	-0.30656E+02	-0.68465E+01	0.37776E+01	0.20000E-03
INTEGRAL OF INPLANE * DM	-0.25000E-02	0.13001E+01	-0.27900E+00	-0.19470E+00	0.95000E-02	-0.17600E-01

MODE NUMBER	7	8	9	10	11
MODE TYPE	COLLECTIVE	COLLECTIVE	COLLECTIVE	NOT USED	NOT USED
NATURAL FREQUENCY,/REV	0.22701E+01	0.30113E+01	0.46845E+01	0.0	0.0
GENERALIZED INERTIA	0.10994E+02	0.22098E+01	0.28077E+01	0.0	0.0
DAMPING RATIO	0.38000E-01	0.27000E-01	0.20000E-01	0.0	0.0
COEF OF INPLANE SHEAR AT HUB,LB	-0.81107E+04	-0.3[illegible]912E+04	0.26935E+05	0.0	0.0
COEF OF OUT-OF-PLANE SHEAR AT HUB,LB	0.66322E+04	-0.26826E+05	0.51157E+05	0.0	0.0
COEF FOR PITCH LINK LOAD,LB	-0.37321E+05	0.11888E+05	-0.71120E+02	0.0	0.0
LEAD-LAG HINGE DISPLACEMENT,DEG	0.0	0.0	0.0	0.0	0.0
INTEGRAL OF OUT-OF-PLANE * R * DM	-0.26732E+01	-0.14912E+01	-0.64790E+00	0.0	0.0
INTEGRAL OF OUT-OF-PLANE * DM	-0.33422E+01	-0.17705E+01	0.18164E+01	0.0	0.0
INTEGRAL OF INPLANE * R * DM	0.77056E+00	-0.14600E+00	-0.28150E+00	0.0	0.0
INTEGRAL OF INPLANE * DM	-0.74260E+00	-0.36280E+00	0.98360E+00	0.0	0.0

Figure 52. Continued.

TABLES USED IN ROTOR WAKE ANALYSIS

MAIN ROTOR TABLE

FLT 35A, SIGMA-PRIME = 0.8636 NMU = 3 NLM = 2 NPH = 6 NRS = 20

MU = 0.26280 LAM = -0.04000

R/R									
0.02	0.7737900	0.0262200	-0.2621800	-0.3864200	0.9963300	0.0198000	-0.2130700	0.3048500	0.3899500
		-0.1028100	-0.1713700	0.1383900	-0.0627800				
0.08	0.6138900	0.2373800	0.0929200	-0.3796800	0.5757600	0.1639300	-0.1031900	0.0856800	0.1834300
		-0.0849800	-0.1126100	0.0549800	0.0544000				
0.14	0.6005800	0.3938500	0.2259200	-0.3318800	0.4340200	0.2995100	-0.0022800	0.0585800	0.0643100
		-0.0270100	-0.0787900	0.0849700	0.0589200				
0.20	0.4487400	0.3654000	0.4281600	-0.1980000	0.1576700	0.1988500	0.1777300	0.1041600	-0.0808500
		-0.0199900	0.0212300	0.0232500	-0.0577100				
0.25	0.3588200	0.4131700	0.5298200	-0.2017100	-0.0377600	0.2302100	0.3032500	0.0532400	-0.1647900
		0.0253000	0.0328900	-0.0450700	-0.0386800				
0.31	0.3815500	0.4279800	0.4329300	-0.0969000	-0.0585700	0.1688900	0.2802900	0.1233800	-0.1507300
		-0.0313900	-0.0312100	-0.0449700	-0.0032500				
0.35	0.3897400	0.4222200	0.4431100	0.0695300	-0.0388100	0.1835800	0.1914200	0.1394800	-0.1514800
		-0.0218200	-0.1003300	-0.0937800	-0.0531500				
0.39	0.3239500	0.3400600	0.4188900	0.1234000	-0.0834100	0.0819600	0.2570900	0.2573500	-0.0875700
		-0.0249200	-0.1592700	-0.0609500	-0.0684900				
0.45	0.2808400	0.2339200	0.3272900	0.2139500	-0.0277900	0.1061000	0.1746200	0.1983900	-0.0685000
		-0.0104400	-0.1212800	-0.0227200	-0.0653500				
0.50	0.3357000	0.1585800	0.4632600	0.3300900	-0.0004100	-0.0696100	0.0551700	0.0444800	0.0169300
		-0.0087400	-0.1830400	-0.1437700	-0.0507500				
0.55	0.4249200	0.1230500	0.4468400	0.2682300	0.0104300	-0.1249800	0.0179300	-0.0288000	-0.0205000
		-0.0575200	-0.1983800	-0.1132700	-0.1019300				
0.59	0.5300400	0.0742300	0.4793400	0.1782800	0.0234800	-0.2110700	-0.0054300	-0.0839500	-0.0578000
		-0.0372900	-0.2371400	-0.0790300	-0.1464100				
0.65	0.6622600	-0.0170500	0.5443000	0.1310200	0.1131100	-0.2475100	0.0092800	-0.1609300	-0.0461700
		-0.0529800	-0.1719100	-0.0392300	-0.1173800				
0.70	0.7235900	-0.3428700	0.7591200	0.1662200	0.4633900	-0.1863100	-0.0371600	-0.4307600	-0.0736000
		-0.1894200	0.0531400	0.0503100	-0.0635800				
0.75	0.896260	-0.3454600	0.7670400	0.1445900	0.4443300	-0.2321900	0.0098100	-0.4165000	-0.0053700
		-0.1512900	0.0943500	0.0669400	-0.0349800				
0.80	1.1549301	-0.4414100	0.8208500	0.0428400	0.4515600	-0.3162800	0.0564000	-0.3340000	0.0028500
		0.0178500	-0.0045500	0.1887500	-0.1546800				
0.85	1.3451099	-0.0190600	0.7183100	0.0510900	0.4972000	-0.2295000	0.1063000	-0.2610300	-0.0634300
		-0.0330800	-0.0786000	0.1149900	-0.1100700				
0.90	1.8131199	-1.0175400	0.6362000	-0.0023300	0.4821100	-0.1410200	0.0514400	-0.1305000	-0.1735400
		-0.0399100	-0.1679300	0.0313200	-0.0045400				
0.95	1.6329403	-0.7744200	0.3307695	-0.5170300	0.4333000	-0.0326600	-0.4491700	0.0747000	-0.1164900
		-0.1034700	0.1712500	-0.1025800	-0.0812500				
1.00	3.1944599	-1.0756903	5.0710602	-1.1787596	1.8679399	-0.6429600	-0.7705500	0.0510500	-1.2957401
		0.3771200	-0.2851300	0.2133900	0.5955800				

MU = 0.26280 LAM = -0.01000

R/R									
0.02	0.7737900	0.0262200	-0.2621800	-0.3804200	0.9963300	0.0198000	-0.2130700	0.3048500	0.3899500
		-0.1028100	-0.1713700	0.1383900	-0.0627800				
0.08	0.6138900	0.2373800	0.0929200	-0.3796800	0.5757600	0.1639300	-0.1031900	0.0856800	0.1834300
		-0.0849800	-0.1126100	0.0549800	0.0544000				
0.14	0.6005800	0.3938500	0.2259200	-0.3318800	0.4340200	0.2995100	-0.0022800	0.0585800	0.0643100
		-0.0270100	-0.0787900	0.0849700	0.0589200				
0.20	0.4487400	0.3654000	0.4281600	-0.1980000	0.1576700	0.1988500	0.1777300	0.1041600	-0.0808500
		-0.0199900	0.0212300	0.0232500	-0.0577100				
0.25	0.3588200	0.4131700	0.5298200	-0.2017100	-0.0377600	0.2302100	0.3032500	0.0532400	-0.1647900
		0.0253000	0.0328900	-0.0450700	-0.0386800				
0.31	0.3815500	0.4279800	0.4329300	-0.0969000	-0.0585700	0.1688900	0.2802900	0.1233800	-0.1507300
		-0.0313900	-0.0312100	-0.0449700	-0.0032500				
0.35	0.3897400	0.4222200	0.4431100	0.0695300	-0.0388100	0.1835600	0.1914200	0.1394800	-0.1514800
		-0.0218200	-0.1003300	-0.0937800	-0.0531500				
0.39	0.3239500	0.3400600	0.4188900	0.1234000	-0.0834100	0.0819600	0.2570900	0.2573500	-0.0875700
		-0.0249200	-0.1592700	-0.0609500	-0.0684900				
0.45	0.2808400	0.2339200	0.3272900	0.2139500	-0.0277900	0.1061000	0.1746200	0.1983900	-0.0685000
		-0.0104400	-0.1212800	-0.0227200	-0.0653500				
0.50	0.3357000	0.1585800	0.4632600	0.3300900	-0.0004100	-0.0696100	0.0551700	0.0444800	0.0169300
		-0.0087400	-0.1830400	-0.1437700	-0.0507500				
0.55	0.4249200	0.1230500	0.4468400	0.2682300	0.0104300	-0.1249800	0.0179300	-0.0288000	-0.0205000
		-0.0575200	-0.1983800	-0.1132700	-0.1019300				
0.59	0.5300400	0.0742300	0.4793400	0.1782800	0.0234800	-0.2110700	-0.0054300	-0.0839500	-0.0578000
		-0.0372900	-0.2371400	-0.0790300	-0.1464100				
0.65	0.6622600	-0.0170500	0.5443000	0.1310200	0.1131100	-0.2475100	0.0092800	-0.1609300	-0.0461700
		-0.0529800	-0.1719100	-0.0392300	-0.1173800				
0.70	0.7235900	-0.3428700	0.7591200	0.1662200	0.4633900	-0.1863100	-0.0371600	-0.4307600	-0.0730000
		-0.1894200	0.0531400	0.0503100	-0.0635800				
0.75	0.8962600	-0.3454600	0.7670400	0.1445900	0.4443300	-0.2321900	0.0098100	-0.4165000	-0.0053700
		-0.1512900	0.0943500	0.0669400	-0.0349800				
0.80	1.1549301	-0.4414100	0.8208500	0.0428400	0.4515600	-0.3162800	0.0564000	-0.3340000	0.0028500
		0.0178500	-0.0045500	0.1887500	-0.1546800				
0.85	1.3451099	-0.0190600	0.7183100	0.0510900	0.4972000	-0.2295000	0.1063000	-0.2610300	-0.0634300
		-0.0330800	-0.0786000	0.1149900	-0.1100700				
0.90	1.8131199	-1.0175400	0.6362000	-0.0023300	0.4821100	-0.1410200	0.0514400	-0.1305000	-0.1735400
		-0.0399100	-0.1679300	0.0313200	-0.0045400				
0.95	1.6329403	-0.7744200	0.3307695	-0.5170300	0.4333000	-0.0326600	-0.4491700	0.0747000	-0.1164900

Figure 52. Continued.

		-0.1034700	0.1712560	-0.1025800	-0.0812500				
1.00	3.1944599	-1.0756903	5.0710602	-1.1767596	1.8679399	-0.6429600	-0.7705500	0.0510500	-1.2957401
		0.3771200	-0.2851300	0.2133900	0.5955800				
X/R	MU =	0.29250 LAM =	-0.04000						
0.02	0.7067500	0.0494600	0.0759500	-0.7938300	0.4744300	0.0851500	0.1274800	-0.1919200	0.3854700
		0.0749700	0.0264400	0.0696100	0.2513700				
0.08	0.6042700	0.1036400	0.3561700	-0.5838000	0.2421800	0.1297900	0.2489400	-0.0931300	0.1661300
		0.0964100	0.0334300	-0.0268900	0.0854000				
0.14	0.5182800	0.1438400	0.5113000	-0.4393400	0.0326100	0.1289700	0.3691900	0.0032500	-0.0199500
		0.0761700	0.0685000	-0.0553700	-0.0410600				
0.20	0.4998100	0.1541700	0.4922800	-0.3488400	-0.0434300	0.0686000	0.3883500	0.1012600	-0.0503300
		0.0174500	0.0246500	-0.0296400	-0.0268100				
0.25	0.5076700	0.1696800	0.4437700	-0.2913500	-0.0783500	0.0239000	0.3874300	0.1714400	-0.0446300
		-0.0180700	-0.0315000	-0.0218900	0.0057300				
0.31	0.5281200	0.2006600	0.5160300	-0.1545700	-0.1258100	-0.0234700	0.4653700	0.3726300	-0.0374400
		-0.0598100	-0.1173900	0.0685800	0.0506800				
0.35	0.5529000	0.2236900	0.4313600	-0.1479100	-0.1368900	-0.0321100	0.4362100	0.3598400	-0.0218900
		-0.0510700	-0.1442900	0.0262300	0.0537800				
0.39	0.5205600	0.1490500	0.4223600	-0.0377000	-0.1007800	-0.0465600	0.3083600	0.2644400	0.0513600
		0.0504500	-0.1151100	-0.0038000	-0.0455100				
0.45	0.4394400	-0.0354400	0.5476400	0.2864300	0.0246100	0.0246300	0.0494400	0.1644700	0.0568100
		0.0848100	-0.1531800	-0.0711700	-0.0883300				
0.50	0.4349700	-0.0739400	0.4301700	0.2460900	0.0126100	-0.0035900	0.0514100	0.1119200	0.0936100
		0.1062200	-0.0796900	-0.0201300	-0.0816200				
0.55	0.4251900	-0.1468700	0.3938600	0.3146500	0.0366400	0.0064800	-0.0325900	0.0246200	0.1295900
		0.1617000	-0.0188300	-0.0001600	-0.1409600				
0.59	0.4628100	-0.1482900	0.3397000	0.3106500	0.0236600	0.0063300	-0.0329400	0.0104800	0.1169400
		0.1445900	-0.0036300	0.0176600	-0.1290000				
0.65	0.5395900	-0.1760300	0.2864500	0.3035000	0.0222800	0.0089900	-0.0388500	-0.0300900	0.0864700
		0.1632900	0.0223000	0.0518900	-0.1112800				
0.70	0.6014300	-0.3072900	0.3622700	0.3194200	0.1176900	0.0475200	-0.0872000	-0.1431500	0.0095200
		0.0175700	0.0926100	0.1275200	-0.0839500				
0.75	0.7907500	-0.3308100	0.3416600	0.2714000	0.1114600	-0.0628000	-0.0595000	-0.2645000	0.0337600
		-0.0068100	0.0692900	0.1016500	-0.1207500				
0.80	1.0062303	-0.4330800	0.4528700	0.2499900	0.2006700	-0.0946900	-0.0229400	-0.2345500	-0.0235800
		-0.0841300	-0.6203800	0.0116000	-0.1469100				
0.85	1.2863703	-0.7641500	0.4518500	0.1607700	0.4071800	-0.0319800	0.1662800	-0.1833000	-0.1251800
		-0.1950300	-0.1331000	-0.1012300	-0.0715600				
0.90	1.8106098	-1.1630497	0.4373300	0.1393600	0.5074100	-0.0133200	0.1708200	-0.1606000	-0.1673600
		-0.2511700	-0.1720700	-0.1498700	-0.0210600				
0.95	1.6714497	-0.9712300	2.3300695	-0.6247700	0.4012800	0.0276900	-0.4653500	0.0960500	-0.1217600
		-0.2574300	0.1965700	-0.2908100	-0.0172100				
1.00	3.2996101	-1.3269961	5.1897898	-1.4179897	1.8893204	-0.7214560	-0.8199800	0.0443200	-1.3644460
		0.3086900	-0.2762600	0.0934500	0.7038600				
X/R	MU =	0.29250 LAM =	-0.01030						
0.02	0.7067500	0.0494600	0.0759500	-0.7938300	0.4744300	0.0851500	0.1274800	-0.1919200	0.3854700
		0.0749700	0.0264400	0.0696100	0.2513700				
0.08	0.6042700	0.1036400	0.3561700	-0.5838000	0.2421800	0.1297900	0.2489400	-0.0931300	0.1661300
		0.0964100	0.0334300	-0.0268900	0.0854000				
0.14	0.5182800	0.1438400	0.5113000	-0.4393400	0.0326100	0.1289700	0.3691900	0.0032500	-0.0199500
		0.0761700	0.0685000	-0.0553700	-0.0410600				
0.20	0.4998100	0.1541700	0.4922800	-0.3488400	-0.0434300	0.0686000	0.3883500	0.1012600	-0.0503300
		0.0174500	0.0246500	-0.0296400	-0.0268100				
0.25	0.5076700	0.1696800	0.4437700	-0.2913500	-0.0783500	0.0239000	0.3874300	0.1714400	-0.0446300
		-0.0180700	-0.0315000	-0.0218900	0.0057300				
0.31	0.5281200	0.2006600	0.5160300	-0.1545700	-0.1258100	-0.0234700	0.4653700	0.3726300	-0.0374400
		-0.0598100	-0.1173900	0.0685800	0.0506800				
0.35	0.5529000	0.2236900	0.4313600	-0.1479100	-0.1368900	-0.0321100	0.4362100	0.3598400	-0.0218900
		-0.0510700	-0.1442900	0.0262300	0.0537800				
0.39	0.5205600	0.1490500	0.4223600	-0.0377000	-0.1007800	-0.0465600	0.3083600	0.2644400	0.0513600
		0.0504500	-0.1151100	-0.0038000	-0.0455100				
0.45	0.4394400	-0.0354400	0.5476400	0.2864300	0.0246100	0.0246300	0.0494400	0.1644700	0.0568100
		0.0848100	-0.1531600	-0.0711700	-0.0883300				
0.50	0.4349700	-0.0739400	0.4301700	0.2460900	0.0126100	-0.0035900	0.0514100	0.1119200	0.0936100
		0.1062200	-0.0796900	-0.0201300	-0.0816200				
0.55	0.4251900	-0.1468700	0.3938600	0.3140500	0.0366400	0.0004800	-0.0325900	0.0246200	0.1295900
		0.1617000	-0.0188300	-0.0001600	-0.1409600				
0.59	0.4628100	-0.1482900	0.3397000	0.3106500	0.0236600	0.0063300	-0.0329400	0.0104800	0.1169400
		0.1445900	-0.0036300	0.0176600	-0.1290000				
0.65	0.5395900	-0.1760300	0.2864500	0.3035000	0.0222800	0.0089900	-0.0388500	-0.0300900	0.0864700
		0.1632900	0.0223000	0.0518900	-0.1112800				
0.70	0.6014300	-0.3072900	0.3622700	0.3194200	0.1176900	0.0475200	-0.0872000	-0.1431500	0.0095200
		0.0175700	0.0928100	0.1275200	-0.0839500				
0.75	0.7907500	-0.3308100	0.3416600	0.2714000	0.1114600	-0.0628000	-0.0595000	-0.2045000	0.0337600
		-0.0068100	0.0692900	0.1016500	-0.1207500				
0.80	1.0062303	-0.4330800	0.4528700	0.2499900	0.2006700	-0.0946900	-0.0229400	-0.2345500	-0.0235800
		-0.0841300	-0.6203800	0.0116000	-0.1469100				
0.85	1.2863703	-0.7641500	0.4518500	0.1607700	0.4071800	-0.0319800	0.1662800	-0.1833000	-0.1251800
		-0.1950300	-0.1331000	-0.1012300	-0.0715600				
0.90	1.8106098	-1.1630497	0.4373300	0.1393600	0.5074100	-0.0133200	0.1708200	-0.1606000	-0.1673600
		-0.2511700	-0.1720700	-0.1498700	-0.0210600				
0.95	1.6714497	-0.9712300	2.3300695	-0.6247700	0.4012800	0.0276900	-0.4653500	0.0960500	-0.1217600
		-0.2574300	0.1965700	-0.2908100	-0.0172100				
1.00	3.2996101	-1.3269961	5.1897898	-1.4179897	1.8893204	-0.7214560	0.8199800	0.0443200	-1.3644460
		0.3086900	-0.2762600	0.0934500	0.7038600				

Figure 52. Continued.

X/R	MU = 0.32120 LAM = -0.04000								
0.02	0.6673300	0.0269200	0.0983900	-0.8526500	-0.0013700	0.0246700	0.1578800	-0.3928000	-0.0770900
		0.0021500	0.1552600	-0.1532200	-0.0674700				
0.08	0.6485700	0.0457500	0.2510800	-0.7396400	-0.0466400	-0.0173900	0.3407600	-0.2183100	-0.0750600
		-0.0708200	0.2196500	-0.0222900	-0.0097600				
0.14	0.5618900	-0.0162600	0.5016200	-0.4570400	-0.1310700	-0.1726600	0.4411000	0.0588300	0.0299800
		-0.1080600	0.1204300	0.0575700	0.0959800				
0.20	0.5762300	0.0104500	0.5420000	-0.3322400	-0.1308000	-0.1709600	0.4694800	0.2032600	0.0685100
		-0.0709600	0.0458600	0.1035600	0.1109200				
0.26	0.6067600	0.0404900	0.5113300	-0.2797600	-0.1213800	-0.1475600	0.4668900	0.2618000	0.0876400
		-0.0311400	-0.0011100	0.1065600	0.1059800				
0.31	0.4983400	-0.1309900	0.6229100	0.0066200	-0.0728300	-0.2330400	0.2454200	0.2083300	0.2693200
		0.1412500	-0.0737200	0.0086900	0.0270200				
0.35	0.5253600	-0.1648300	0.5674400	0.0175600	-0.0749000	-0.2094400	0.2243100	0.1945700	0.2587500
		0.1583000	-0.0769800	0.0049100	-0.0067500				
0.39	0.5127100	-0.1479300	0.5639800	0.1055900	-0.0505000	-0.2030500	0.1236500	0.1206200	0.2968500
		0.2395000	-0.0453000	-0.0142900	-0.1065200				
0.44	0.4734300	-0.2751100	0.5448100	0.2068400	0.0702600	-0.0769600	0.0012800	0.0084100	0.1978200
		0.1928100	0.0398000	0.0526000	-0.1083600				
0.50	0.5171400	-0.2510300	0.4946300	0.2225500	0.0581200	-0.0395200	-0.0095400	0.0070900	0.1580400
		0.1660000	0.0315500	0.0481200	-0.1048800				
0.55	0.5644300	-0.2350400	0.4455200	0.2374400	0.0420400	-0.0159900	-0.0176000	0.0048600	0.1261900
		0.1414100	0.0278100	0.0482100	-0.0978500				
0.59	0.6040200	-0.2312000	0.3990000	0.2396500	0.0211700	-0.0144500	-0.0165600	0.0025400	0.1188300
		0.1314700	0.0302000	0.0511200	-0.0916100				
0.65	0.6173300	-0.3544800	0.3578800	0.2945800	0.0974600	0.0791600	-0.0810500	-0.0883000	0.0334100
		0.0587400	0.1201100	0.1432200	-0.0412400				
0.70	0.6575200	-0.4577000	0.2863900	0.2681300	0.1469700	0.1397700	-0.0274600	-0.0221500	-0.0235500
		0.0086400	0.0488000	0.0681500	-0.0079500				
0.75	0.7717100	-0.5035400	0.2331300	0.2751300	0.1247500	0.1288800	-0.0147700	-0.0146600	-0.0238200
		0.0007200	0.0320600	0.0484600	-0.0080500				
0.80	0.9551400	-0.5993600	0.1860200	0.2863000	0.1108300	0.1119800	-0.0030400	-0.0265800	-0.0253800
		-0.0163300	0.0181400	0.0260800	-0.0104700				
0.85	1.2242603	-0.7633400	0.1321500	0.3116600	0.1186100	0.0960000	0.0179300	-0.0398800	-0.0339900
		-0.0417600	0.0003600	0.0033300	-0.0120800				
0.90	1.7455947	-1.1896801	0.0846800	0.3461700	0.2128600	0.1543800	0.0066700	-0.0099000	-0.1179500
		-0.1400300	-0.0816000	-0.1091100	0.0059100				
0.95	1.5737600	-0.9706100	2.0542602	-0.5395400	0.1235900	0.1978200	-0.5777500	0.2581100	-0.0591100
		-0.1882100	0.2931800	-0.3102500	-0.0086400				
1.00	3.2205601	-1.3789196	4.9686603	-1.4356203	1.6706400	-0.6487600	-0.9133800	0.1817800	-1.3223000
		0.4154600	-0.1950800	0.0921800	0.7243700				

X/R	MU = 0.32120 LAM = -0.01600								
0.02	0.6673300	0.0269200	0.0983900	-0.8526500	-0.0013700	0.0246700	0.1578800	-0.3928000	-0.0770900
		0.0021500	0.1552600	-0.1532200	-0.0674700				
0.08	0.6485700	0.0457500	0.2510800	-0.7396400	-0.0466400	-0.0173900	0.3407600	-0.2183100	-0.0750600
		-0.0708200	0.2196500	-0.0222900	-0.0097600				
0.14	0.5618900	-0.0162600	0.5016200	-0.4570400	-0.1310700	-0.1726500	0.4411000	0.0588300	0.0299800
		-0.1080600	0.1204300	0.0575700	0.0959800				
0.20	0.5762300	0.0104500	0.5420000	-0.3322400	-0.1308000	-0.1709600	0.4694800	0.2032600	0.0685100
		-0.0709600	0.0458600	0.1035600	0.1109200				
0.26	0.6067600	0.0404900	0.5113300	-0.2797600	-0.1213800	-0.1475000	0.4668900	0.2618000	0.0876400
		-0.0311400	-0.0011100	0.1065600	0.1059800				
0.31	0.4983400	-0.1309900	0.6229100	0.0066200	-0.0728300	-0.2330400	0.2454200	0.2083300	0.2693200
		0.1412500	-0.0737200	0.0086900	0.0270200				
0.35	0.5253600	-0.1648300	0.5674400	0.0175600	-0.0749000	-0.2094400	0.2243100	0.1945700	0.2587500
		0.1583000	-0.0769800	0.0049100	-0.0067500				
0.39	0.5127100	-0.1479300	0.5639800	0.1055900	-0.0505000	-0.2030500	0.1236500	0.1206200	0.2968500
		0.2395000	-0.0453000	-0.0142900	-0.1065200				
0.44	0.4734300	-0.2751100	0.5448100	0.2068400	0.0702600	-0.0709600	0.0012800	0.0084100	0.1978200
		0.1928100	0.0398000	0.0526000	-0.1083600				
0.50	0.5171400	-0.2510300	0.4946300	0.2225500	0.0581200	-0.0395200	-0.0095400	0.0070900	0.1580400
		0.1660000	0.0315500	0.0481200	-0.1048800				
0.55	0.5644300	-0.2350400	0.4455200	0.2374400	0.0420400	-0.0159900	-0.0176000	0.0048600	0.1261900
		0.1414100	0.0278100	0.0482100	-0.0978500				
0.59	0.6040200	-0.2312000	0.3990000	0.2396500	0.0211700	-0.0144500	-0.0165600	0.0025400	0.1188300
		0.1314700	0.0302000	0.0511200	-0.0916100				
0.65	0.6173300	-0.3544800	0.3578800	0.2945800	0.0974600	0.0791600	-0.0810500	-0.0883000	0.0334100
		0.0587400	0.1201100	0.1432200	-0.0412400				
0.70	0.6575200	-0.4577000	0.2863900	0.2681300	0.1469700	0.1397700	-0.0274600	-0.0201500	-0.0235500
		0.0086400	0.0488000	0.0681500	-0.0079500				
0.75	0.7717100	-0.5035400	0.2331300	0.2751300	0.1247500	0.1288800	-0.0147700	-0.0146600	-0.0238200
		0.0007200	0.0320600	0.0484600	-0.0080500				
0.80	0.9551400	-0.5993600	0.1860200	0.2863000	0.1108300	0.1119800	-0.0030400	-0.0265800	-0.0253800
		-0.0163300	0.0181400	0.0260800	-0.0104700				
0.85	1.2242603	-0.7633400	0.1321500	0.3116600	0.1186100	0.0960000	0.0179300	-0.0398800	-0.0339900
		-0.0417600	0.0003600	0.0033300	-0.0120800				
0.90	1.7455947	-1.1896801	0.0846800	0.3461700	0.2128600	0.1543800	0.0066700	-0.0099000	-0.1179500
		-0.1400300	-0.0816000	-0.1091100	0.0059100				
0.95	1.5737600	-0.9706100	2.0542602	-0.5395400	0.1235900	0.1978200	-0.5777500	0.2583100	-0.0591100
		-0.1882100	0.2931800	-0.3102500	-0.0086400				
1.00	3.2205601	-1.3789196	4.9686603	-1.4356203	1.6706400	-0.6487600	-0.9133800	0.1817800	-1.3223000
		0.4154600	-0.1950800	0.0921800	0.7243700				

Figure 52. Concluded.

6.3.7 Maneuver Specification (Figure 53)

The program prints the contents of the maneuver time card (CARD 291) and all maneuver control cards (all 301-type cards, the J-cards) before starting the trim procedure. A program-supplied title for the action caused by each J-card is included to the left of the numerical inputs of the J-cards. This serves as a record of the type of maneuver specified as well as a quick way to check the input data.

6.3.8 Airfoil Data Table Printout

The sets of Airfoil Data Tables input in the Data Table Group are printed in their order of input. If the internal NACA 0012 table is used, it is printed last. Each set consists of three independent tables in the following order: lift, drag, and pitching moment coefficients. The Mach number values are listed across the page, and angle of attack values are listed down the page. The inputs on the title card of each set of tables precede the printout of each set. Each table in each set is identified. See Figure 28 for the printout of the 0012 airfoil table.

6.3.9 Rotor-Induced Velocity Distribution (RIVD) Table Printout

The RIVD table is printed only when it is included in the input data. The printout heading is "TABLES USED IN ROTOR WAKE ANALYSIS" and is followed by the table title, and a statement of the number of advance ratios (NMU), inflow ratios (NLM), harmonics (NHH), and radial stations (NRS). The sets of coefficients are then printed in essentially the same format used for input, i.e., the table for the first set of advance and inflow ratios, followed by the table for the second set, etc. The heading for each table includes the advance ratio and inflow ratio. For each table the NRS values of radial station are listed in the leftmost column. The first number to the right of the X/R value is the constant coefficient; the next two are the sine and cosine coefficients, respectively, for the first harmonic; the next two are for the second harmonic, etc. If more than four harmonics are included, the fifth harmonic pair is printed immediately below the first harmonic pair. The printout of four pairs of coefficients per line continues until all coefficients are printed for the first value of X/R. The succeeding sets of coefficients for each value of X/R are printed in the same format.

INPUT DATA FOR MANEUVER

START (SEC)	DELT1 (SEC)	MAX1 (SEC)	DELT2 (SEC)	MAX2 (SEC)	MAX3 (SEC)
0.0	7.500000	2.000000	7.500000	0.0	0.0

	J	XCIT(J,1)	(J,2)	(J,3)	(J,4)	(J,5)	(J,6)
COLLECTIVE STICK	1	0.0	0.0	3.000	3.000	-0.140	7.500
COLLECTIVE STICK	1	7.500	0.0	9.000	9.000	0.0	10.000
P-TRACKER AUTO PILOT	41	0.0	0.0	0.550	0.550	6.963	2.100
P-TRACKER AUTO PILOT	41	2.100	0.0	2.300	2.300	6.727	2.850
P-TRACKER AUTO PILOT	41	2.850	-3.273	3.400	3.400	2.000	3.700
P-TRACKER AUTO PILOT	41	3.700	-6.500	4.900	4.900	-7.500	5.900
P-TRACKER AUTO PILOT	41	5.900	8.750	6.300	6.300	-5.714	6.900
P-TRACKER AUTO PILOT	41	6.900	8.000	7.400	7.400	0.0	9.000
Q-TRACKER AUTO PILOT	42	0.0	0.0	1.100	1.100	2.222	1.550
Q-TRACKER AUTO PILOT	42	1.550	-0.909	2.650	2.650	3.185	4.000
Q-TRACKER AUTO PILOT	42	4.000	7.083	5.200	5.200	0.0	8.000
Q-TRACKER AUTO PILOT	42	8.000	-3.000	9.000	9.000	0.0	10.000
R-TRACKER AUTO PILOT	43	0.0	5.400	0.500	0.500	-3.333	2.000
R-TRACKER AUTO PILOT	43	2.000	2.520	4.500	4.500	8.125	5.300
R-TRACKER AUTO PILOT	43	5.300	-3.692	6.600	6.600	6.333	7.000
R-TRACKER AUTO PILOT	43	7.000	-1.176	9.000	9.000	0.0	10.000
SIMULATE AUTO PILOT	32	0.0	100.000	100.000	100.000	0.100	0.100

Figure 53. Maneuver Specification.

6.4 TRIM ITERATION PAGE (Figure 54)

If IPL(72) = 1, a trim iteration page is printed for each trim iteration computed.

6.4.1 Parameters in Iterations

The VAR(I) array printed across the top of the page gives the current values of the variables which are changed during the trim procedure. The title of each variable is printed directly above its current value.

6.4.2 Rotor Performance

The two rows below the VAR(I) array give the following quantities for the two rotors:

- Thrust in shaft reference (lb)
- H-Force in shaft reference (lb)
- Y-Force in shaft reference (lb)
- Torque (Z component) in shaft reference (ft-lb)
- Average induced velocity (ft/sec)

The values of the left and right jet thrusts are also included in this block of data.

6.4.3 Force and Moment Summary

This block of output shows the contribution to the total forces and moments of each component of the rotorcraft that is included in the input data. The X-force, Y-force, Z-force, roll moment, pitch moment, and yaw moment are in body reference, with the forces in pounds and the moments in foot-pounds.

Each force and moment forms one column of the summary, where each row corresponds to a component of the rotorcraft. Except for the JETS AND GUNS row, only the components for which an input group was included are printed. If, for example, only two stabilizing surfaces were input, the rows for Stabilizing Surfaces No. 3 and No. 4 will not be printed. The complete list of possible rows in order is as follows:

FUSELAGE

MAIN ROTOR

TAIL ROTOR

RIGHT WING

***** START OF OS ITERATION 6 *****

INDEPENDENT VARIABLES

COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL	PITCH	YAW	MR F/A FLAP	MR LAT FLAP	TR F/A FLAP	TR LAT FLAP
37.99635	66.72765	55.71921	47.51226	-3.31966	-3.76912	-1.67368	-0.72002	-1.11827	1.65416

	THRUST	H-FORCE	Y-FORCE	TORQUE	IND. V.	JET THRUST	
MAIN ROTOR	7346.	-76.	-170.	10852.	6.096	RIGHT/CENTER	0.
TAIL ROTOR	-260.	17.	-4.	49.	-5.697	LEFT	0.

FORCE AND MOMENT SUMMARY

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW	F/A MOM	LAT MOM
FUSELAGE	-375.3	-29.1	71.4	-144.8	-1210.3	-782.5		
MAIN ROTOR	76.0	-176.2	-7345.7	-1262.1	-1692.2	-8.5	263.2	-866.9
TAIL ROTOR	-17.2	259.6	-3.7	1083.4	-25.8	-6965.0	0.0	-0.0
RIGHT WING	-75.4	-29.6	-480.0	-1141.8	436.5	152.5		
LEFT WING	-75.0	25.2	-473.1	1125.5	430.3	-155.3		
STABILIZER #1	-13.0	126.5	1.1	307.4	59.4	-3174.1		
STABILIZER #2	-2.1	-0.1	15.5	23.6	290.7	4.1		
STABILIZER #3	-2.1	-0.1	15.4	-24.4	288.6	-2.4		
GROSS WEIGHT	481.7	-178.6	8303.1					
M.R. TORQUE				0.0	-0.0	10852.3		
T.R. TORQUE				0.0	-88.9	-0.0		
TOTAL	-2.4	3.8	104.2	26.7	11.2	-19.1		

FORCE AND MOMENT SUMMARY

WIND AXIS	DRAG(AFT) FORCE	SIDE FORCE	LIFT(UP) FORCE	ROLL MOMENT	PITCH MOMENT	YAW MOMENT
FUSELAGE	379.2	-23.6	-49.7	-117.2	-1208.7	-789.5
MAIN ROTOR	-496.4	-177.5	7329.1	-1262.0	-151.6	-77.7
TAIL ROTOR	13.1	259.9	4.7	1478.8	-47.5	-6831.1
RIGHT WING	48.1	-28.9	483.5	-1142.1	453.3	86.4
LEFT WING	47.2	25.9	476.7	1138.7	413.7	-96.2
STABILIZER #1	11.2	126.7	-0.4	490.5	52.2	-3151.4
STABILIZER #2	3.6	-6.0	-15.4	27.6	290.3	5.5
STABILIZER #3	3.0	-0.0	-15.3	-20.0	288.9	-3.8
GROSS WEIGHT	-0.0	-176.6	-8317.1			
M.R. TORQUE				-625.1	9.2	10834.3
T.R. TORQUE				-1.3	-88.9	-0.0
TOTAL	8.3	3.9	-103.8	27.9	10.8	-17.5

HARMONIC ANALYSIS OF BLADE DEPENDENT PARTICIPATION FACTORS FOR ROTOR 1

MODE NUMBER	1	2	3	4	5	6
	7	8	9	10	11	
STEADY	.0	.0	.0	.0	.0	-.3922449
	-.1857482E-01	-.1032928E-01	-.1181917E-01	.0	.0	
COSINE 1/REV	.6426485	.2600227E-01	.2824602E-02	.5337764E-02	-.7177676E-03	.0
	.0	.0	.0	.0	.0	
SINE 1/REV	.2764663	-.6078187E-01	-.1607195E-01	-.5861478E-01	-.4065607E-02	.0
	.0	.0	.0	.0	.0	

PARTIAL DERIVATIVE MATRIX

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	YAW MOM	PITCH MOM	ROLL MOM	MR F/A MOM	MR LAT MOM	TR F/A MOM	TR LAT MOM
COLLECTIVE	4062.	-4019.	-151977.	88377.	-21094.	-28389.	20453.	1030995.	0.	0.
F/A CYCLIC	930.	2554.	65838.	46703.	-23471.	18029.	-1181.	-1311220.	0.	0.
LAT CYCLIC	-1338.	4615.	1391.	-34225.	9381.	32597.	-1153589.	-1114.	0.	0.
PEDAL	258.	-6858.	54.	182620.	1341.	-28669.	0.	0.	-414.	6918.
PITCH	-6830.	-1321.	-64327.	-5291.	-17214.	-12629.	2001.	247012.	-387.	-67.
YAW	-395.	11962.	2910.	-63401.	1525.	23567.	-90363.	-27199.	88.	-1267.
MR F/A FLAP	-4365.	30.	9225.	38965.	30368.	212.	232956.	-1065024.	0.	0.
MR LAT FLAP	1066.	2420.	-11944.	27762.	-6887.	17691.	1147572.	256926.	0.	0.
TR F/A FLAP	259.	-14.	168.	72.	2729.	136.	0.	0.	9984.	-8635.
TR LAT FLAP	273.	-2675.	-229.	71011.	-6392.	-11477.	0.	0.	10131.	10249.
-ERROR	2.	-4.	-104.	19.	-11.	-27.	-203.	881.	-0.	0.

Figure 54. Trim Iteration Page.

LEFT WING
STABILIZER #1
STABILIZER #2
STABILIZER #3
STABILIZER #4
JETS AND GUNS
STORE/BRAKE #1
STORE/BRAKE #2
STORE/BRAKE #3
STORE/BRAKE #4
GROSS WEIGHT
M.R. TORQUE
T.R. TORQUE
TOTAL

Note that the rows labeled M.R. TORQUE and T.R. TORQUE include the moment due to flapping restraint as well as the body axis components of the appropriate shaft axis rotor torques. The rows labeled MAIN ROTOR and TAIL ROTOR include only the effects of the rotor forces acting at each hub when resolved to the cg. The drag of the rotor pylons, computed from XMR(40) and XTR(40), in wind reference, is resolved into body reference and included in the FUSELAGE forces and moments.

The user may also get a summary of the forces and moments acting upon the aircraft center of gravity expressed in the wind-axis coordinate system by setting IPL(74) to a nonzero value. The wind-axis coordinate system used is the one at the aircraft center of gravity, and is rotated from the body axis through the fuselage angle-of-attack and the fuselage aerodynamic yaw angle.

6.4.4 Partial Derivative Matrix

This matrix gives the partial derivative of each force and moment with respect to each of the iteration variables. The units are pounds per radian on the force derivatives and foot-pounds per radian on the moment derivatives. For the controls, the angles are rotor blade angles. The line labeled -ERROR gives the negative of the force and the moment imbalances at this iteration. If IPL(45) = 0 or 5, this matrix is computed and printed at every fifth iteration; otherwise, it is computed and printed every IPL(45)th iteration.

6.4.5 Correction Array

The line labeled CORRECTIONS gives the computed changes in the iteration variables array VAR(I), in radians. They are in the same order as the VAR(I) and the partial derivative rows. It is printed only when one or more of the computed corrections is greater than the maximum allowed by variable damper procedures. If such a case occurs, the computed corrections are multiplied by a ratio that will make all corrections within the allowable range, and this ratio is printed along with the sequence number of the iteration variable that determined it. The ratioed corrections are then added to the iteration variables to determine the values for the next iteration. It should be noted again that the CORRECTIONS are in radians and not in the same units as the VAR(I). The printing of this array generally indicates that the inputs for the maximum allowable corrections were too small or that the values of VAR(I) may not be converging to a trim solution. The array is most useful when a case does not trim, since it indicates which VAR(I) is preventing trim.

6.5 TRIMMED FLIGHT CONDITION PAGES

Two types of printouts are possible for the data computed in the last trim iteration, the standard trim page and the optional trim page. The standard trim page is always printed. If the optional trim page is to be printed, it follows the standard trim page if only a quasi-static trim is computed. The user may also get a summary of the forces and moments acting upon the aircraft center of gravity expressed in the wind-axis coordinate system by setting IPL(74) to a nonzero value. The wind-axis coordinate system used is the one at the aircraft center of gravity, and is rotated from the body axis through the fuselage angle-of-attack and the fuselage aerodynamic yaw angle.

When performing a quasi-static trim followed by a time-variant trim, the standard trim page will be printed twice with data regarding the time-variant trim printed in between the two. The second trim page will be an update of the first page, reflecting the effects of the time-variant trim. If the switch to print the optional trim page is turned on, the optional page will be printed after the blade bending moment data are printed out. The data printed out during a time-variant trim is discussed in Section 6.6.

6.5.1 Standard Trim Page (Figure 55)

This page follows the final trim iteration. The final iteration occurs either when all forces and moment imbalances are within their respective allowable errors (XIT(50) through

```
BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAPBC01   COMPUTED  06/19/81

              AH-1G + OLS ROTOR SIMULATION         AGAP80 ARMY VERSION
              OLS COUNTER 615. FLIGHT 35A. 2900* HP, 27 DEG C  (PAN NAME C61STRMT
              ELASTIC ROTOR, HSOFT = -17.0          OUTPUT TO GO INTO INPUT GUIDE                NPART = 1
        ROTORCRAFT IS TRIMMED AFTER 16 ITERATIONS.      0.256 MINUTES ELAPSED COMPUTING TIME.
                                    --------------------ATMOSPHERIC CONDITIONS (ICAO)------------------------------------------
                                    DENSITY ALTITUDE  (FT)   4927.         ALTITUDE ABOVE GROUND  (FT)      1000.00
PRESSURE ALTITUDE  (FT)    2900.    DENSITY RATIO            0.8636        SPEED OF SOUND      (FT/SEC)    1140.19
TEMPERATURE      (DEG C)   27.00
                                                                           ------------BLADE-----------     -JET THRUST-
                                            ------------POWER/TORQUE-----------  TIP   ADV BLD   INERTIA          LBS
----WEIGHTS----     CENTER OF GRAVITY (IN)            SHAFT    TORQUE   SPEED    SPEED MACH NO  SLUG-FT-SQ   RT      0.0
    POUNDS           S.L.     B.L.    W.L.          HORSEPOWER  FT-LB    RPM     747.   0.846   1503.388     LT      0.0
BASIC A/C   8319.   200.60    0.0     68.00    MAIN   672.54   10899.9  324.1    737.   0.838      1.532
STORES        0.                               TAIL    28.09      89.1 1656.6
TOTAL       8319.   200.60    0.0     68.00    ENG    760.63     557.5 6600.0

                                                   BODY REFERENCE
                               U          V          W          P          Q          R
                   VELOCITY  217.848    3.214    -12.553       0.0        0.0        0.0
                                        ---------------------------AERODYNAMIC SURFACES---------------------     AERODYNAMIC ANGLE
                                                                         -----BODY AXIS FORCES------            ATTACK  SIDESLIP
------FLIGHT PATH CONDITION-------                ANGLE OF     FLAP                                              3.65    -3.30
TRUE AIRSPEED       (KNOTS)    129.30   SURFACE   INCIDENCE   ANGLE    X +FWD    Y +RIGHT   Z +DOWN             -1.23     0.84
GROUND SPEED        (KNOTS)    129.30   NO. 1       4.50       0.0     -13.0      126.4       1.1
RATE OF CLIMB      (FT/SEC)      0.0    NO. 2       2.77       0.0      -2.1       -0.1      15.7               -1.23     0.84
CLIMB ANGLE          (DEG)       0.0                                              -0.1      15.6                 0.0      0.0
HEADING ANGLE        (DEG)       0.0    NO. 3       2.77       0.0      -2.1       0.0       0.0
ANGLE OF ATTACK      (DEG)      -3.30   NO. 4       0.0        0.0       0.0                                    10.76     1.03
ANGLE OF SIDESLIP    (DEG)       0.85                                             -29.7    -480.2               10.66     0.66
ANGLE OF AERO YAW    (DEG)      -0.84   RT WING    14.00       0.0     -75.4       25.2    -473.3
ACCELERATIONS  VERT   (G)        1.00   LT WING    14.00       0.0     -75.0
               FWD    (G)        0.06
               LAT    (G)       -0.02
                                                  GROUND REFERENCE
                           EULER ANGLES TO BODY REFERENCE          DISPLACEMENTS
                              PSI        THETA       PHI         X          Y          Z
                 VELOCITY     0.0         0.0        0.0      218.233      0.0        0.0
                 LOCATION    -0.773      -3.315     -1.232
                                                                           --HUB-MAST-PYLON-----------(MAIN)---(TAIL)-
                         -------------SWASH PLATE ANGLE (DEGREES)-------------  DELTA 3          (DEG)      0.0     45.0
CONTROL DISPLACEMENTS    -------MAIN ROTOR--------   -------TAIL ROTOR-------  PHASING          (DEG)      0.0      0.0
      ---PERCENT---       COLL     F/A      LAT       COLL     F/A      LAT    HUB SPRING MOMENT F/A      -0.      0.
                         15.43     0.0      0.0        0.0     0.0      0.0           (FT-LB)   LAT       0.      0.
COLL        (UP)  38.53   0.0      5.40     0.0        0.0     0.0      0.0    PYLON ANGLES      F/A     0.0      0.0
F/A CYC    (FWD)  68.63   0.0      0.0     -1.60       0.0     0.0      0.0                (DEG) LAT     0.0      0.0
LAT CYC     (RT)  55.71   0.0      0.0      0.0       -3.40    0.0      0.0    MAST ANGLE  (DEG) F/A     0.0      0.0
PEDAL       (LT)  47.57   0.0      0.0      0.0        0.0     0.0      0.0                      LAT     0.0    -90.00
SUM OF PYLON AND SCAS     0.0      0.0      0.0        0.0     0.0      0.0
TOTAL SWASH PLATE ANG    15.43     5.40    -1.60      -3.40    0.0      0.0
                                                                                                              INDUCED
                                                 -------ROTORS-------------------------     ADVANCE   CP        CT     VELOCITY
                                                 FORCES (SHAFT AXIS) POUNDS                RATIO    X10**5    X10**4     6.16
-------------------------------------------------THRUST    H-FORCE    Y-FORCE              0.292    28.467    42.790    -5.72
     BLADE FEATHERING - DEG     FLAPPING - DEG   7447.54    -78.99    -174.46              0.296    33.000   -41.162
      MEAN    PSI=0   PSI=90     F/A      LAT    -260.74     17.25      -3.71
MAIN  15.43   1.60    -5.40    -1.682   -0.739                                               HUB MOTION (FT)          MAST
TAIL  -3.40  -1.12     1.06    -1.125    1.056                                                                        WIND-UP
                                          SHAFT AXIS DATA AT ROTOR HUB                                                (DEG)
                       BETA                                 SHEAR FORCES (POUNDS)        X        Y        Z           0.0
                 HUB      LIMIT       VELOCITIES (FT/SEC)                                 0.0      0.0      0.0         0.0
    PSI (DEG)   (DEG)     (DEG)       U         V         W        X         Y          Z    0.0      0.0      0.0
MAIN   0.0       0.0      12.00     217.85     3.21    -12.55    260.0    -241.5    -6161.2
TAIL   0.0       0.0      11.00     217.85   -12.55      2.57    -17.2      -3.7      260.7
```

Figure 55. Trimmed Flight Condition Page.

XIT(63)), or after XIT(1) iterations have been performed. If XIT(1) iterations were executed without trimming, the page is printed even though the rotorcraft is not actually trimmed. However, program execution terminates immediately after the printout. When the page is printed because the imbalances are within the prescribed limits, the program continues on to subsequent operations or cases.

The data are printed in blocks as discussed below.

6.5.1.1 Problem Identification

The problem identification consists of a line containing the name of the program and the date the job was computed followed by the alphanumeric comments input on CARDS 02, 03, and 04.

6.5.1.2 Trim Condition Specification

A one-line message is printed, stating whether or not the rotorcraft is in a trimmed flight condition, the number of trim iterations used, the computer CPU time used, and the value of NPART. As implied above, the rotorcraft is termed trimmed when the imbalances are less than the allowable errors, and not trimmed when XIT(1) iterations are performed without the imbalances being less than the allowable errors.

6.5.1.3 Atmospheric Parameters

This block of data describes the atmospheric conditions in which the rotorcraft was trimmed. These quantities are all consistent and conform with the standard atmosphere prescribed by the International Civil Aviation Organization (ICAO). This defined atmosphere is the same as the 1962 United States standard.

6.5.1.4 Physical and Power Parameters

Data on the rotorcraft weight and center-of-gravity location are presented immediately below the left end of the atmospheric data. The data include the weight and cg location without external stores, the total weight of all external stores, and the gross weight and cg location with stores. The stores-on data are those that are used during the trim procedure. The other data are for reference only.

To the right of the weight and cg data and in the center of the page are the power and torque required for each rotor and the accessories. The total required horsepower includes the effects of the efficiency ratios.

To the right of the power and torque data are rotor blade parameters. Tip speed is in feet per second, and advancing blade Mach number is computed at the blade tip. Blade flapping inertia is for a single blade.

To the right of the blade data are the thrusts of the right and left jets in pounds.

6.5.1.5 Body Reference Parameters

The linear and angular velocities of the rotorcraft in the Body Reference System are printed immediately below the physical and power parameter printout. The sequence of outputs is X, Y, and Z linear velocities in feet per second followed by the roll, pitch, and yaw angular velocities in degrees per second.

6.5.1.6 Flightpath and Aerodynamic Surface Parameters

Below the body reference data are the parameters which define and orient the rotorcraft with respect to the flightpath. True airspeed is the airspeed along the flightpath and is equal to the groundspeed only when the rate of climb is zero. (The program assumes that with no gusts the air mass is stationary with respect to the ground.) The climb and heading angles are defined in Section 6.2.3.1. The three aerodynamic angles and accelerations are defined in Sections 6.2.3.2 and 6.2.3.4 respectively. Note that the three accelerations are in the Body Reference System.

The aerodynamic surface parameters are to the right of the flightpath conditions. These parameters consist of the angle of incidence; flap or control surface angle; body axis X, Y, and Z forces; and aerodynamic angles for the right and left panels of the wing and for each of the four stabilizing surfaces. The aerodynamic angles are defined like the fuselage angles in Section 6.2.3.2 except that the velocities used in the definition are in the Aerodynamic Surface Reference System rather than in the Body Reference System.

6.5.1.7 Ground Reference Parameters

Below the flightpath and aerodynamic surface data are the ground reference parameters. The location and rates of change of the three ground-to-body Euler angles are printed in degrees and degrees per second, respectively.

6.5.1.8 Flight and Rotor Control Parameters

Below and to the left of the ground reference parameters are the positions of the four primary flight controls in percent. To the right of the control positions is a matrix of the con-

tributions of each of these controls plus the pylon and SCAS to each of the swashplate angles of each rotor. The entries in the bottom row of the matrix are simply the summation of the column above them. All entries are in degrees and these swashplate angles are applied to the rotor (collectively and cyclicly) at the center of rotation. The collective pitch of the swashplate would be more properly expressed as a vertical displacement of the swashplate or collective pitch sleeve. However, the control system model is not currently capable of providing these data.

To the right of the control contribution matrix are data for the hub, mast, and pylon plus the values of the pitch-flap-coupling and control-phasing angles. The mast angle and pylon deflections are defined in Table 25. The hub-spring moments are in the Rotor Shaft Reference System.

6.5.1.9 <u>Rotor Parameters</u>

Below the controls data are the rotor parameters. This output group consists of the blade feathering, flapping, rotor forces, advance ratio, power and thrust coefficients, and induced velocity for each rotor. All parameters are in a Rotor Shaft Reference System. The blade feathering angles are measured at the theoretical blade root (Station No. 0). The mean blade feathering angle is identical to the collective pitch printed in the controls matrix. The longitudinal feathering angle (PSI = 0) and lateral angle (PSI = 90) will differ from the F/A and LAT swashplate angles when the value of the pitch-flap-coupling angle minus the control-phasing angle ($\delta_3 - \gamma$) is nonzero. Sign conventions for the flapping angles are defined in Section 6.2.1. Thrust is positive up the rotor shaft. H-force and Y-force are positive in the direction of the positive shaft reference X and Y axes, respectively.

$$\text{ADVANCE RATIO} = \mu = \frac{\text{velocity in the shaft X-Y plane}}{\text{rotor tip speed}}$$

and is dimensionless.

The power coefficient is defined as

$$CP = \text{power}/(\rho\,\pi\,R^2(\Omega R)^3)$$

and the thrust coefficient as

$$CT = \text{thrust}\,/(\rho\,\pi\,R^2(\Omega R)^2)$$

where ρ = air density (slug/ft^3)

R = rotor radius (ft)

ΩR = rotor tip speed (ft/sec)

Both coefficients are dimensionless. The nondimensionalization factors used here are not the same as those used in the optional trim page.

The induced velocity is the average value over the rotor disc in feet per second.

The next two lines on the trim page give the hub flapping angles for both rotors (which are equal to zero for a quasi-static rotor), the hub velocities in shaft reference, the steady component of the hub shears and displacements, and the mean mast windup angle, in degrees.

6.5.2 Optional Trim Page (Figure 56)

Printout of this page is controlled by IPL(73). The optional trim page is most useful for presenting data from a wind tunnel simulation.

6.5.2.1 Problem Identification

The standard trim page heading with comment cards is repeated at the top of the optional trim page(s).

6.5.2.2 Parameter Listing

Four blocks of data are printed across the page below the problem identification: rotor controls, rotor parameters, (wind) tunnel parameters, and program options. The items printed are generally either self-explanatory or have been explained previously. The dimensions, if any, for all parameters are included in the printout.

If the blade chord is not constant, the average value of chord is printed.

If the blade geometric twist is not linear, the printed twist value is the total twist angle between the root and the tip.

The solidity parameter, σ, is defined as $\sigma = b\bar{c}/\pi R$

where b = number of blades

$\bar{c}$ = average chord

R = rotor radius

6.5.2.3 Forces and Moments

The rotor forces and moments printed below the parameter are listed in both the wind reference and shaft reference systems. Rotor power is printed in the shaft axis columns only. Each set of data consists of two nondimensional coefficients and the dimensional values for each force and moment. The factors that

BELL HELICOPTER TEXTRON   ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001   COMPUTED 06/19/81

AH-1G + ULS ROTOR SIMULATION   AGAP80 ARMY VERSION
ULS COUNTER 615, FLIGHT 35A, 2900' HP, 27 DEG C   (PAN NAME CBIRTRMT
ELASTIC ROTOR, HSOFT = -17.0   OUTPUT TO GO INTO INPUT GUIDE

ROTOR CONTROLS		ROTOR PARAMETERS		TUNNEL PARAMETERS		PROGRAM OPTIONS	
COLLECTIVE PITCH	15.428 DEG	ROTOR SPEED	324.06 RPM	FORWARD SPEED	129.30 KTS	NO INPUT MODES	9
F/A CYCLIC PITCH	5.400 DEG	SOLIDITY	0.0631	ADVANCE RATIO	0.2923	MX YAW FLOW, TIP	0.0 DEG
LAT CYCLIC PITCH	-1.601 DEG	BLADE RADIUS	22.00 FT	ADV TIP MACH NO	0.846	AERODYNAMICS, TIP	TABLE
TOT CYC FEATHER	5.633 DEG	CHORD, AVG	26.18 IN	SIGMA PRIME	0.864	TORSION	ON
DELTA 3	0.0 DEG	PRECONE	2.75 DEG	MAST TILT ANGLE	0.0 DEG	NON STEADY AERO	OFF
F/A FLAP ANGLE	-1.613 DEG	CONING	-1.151 DEG	TPP ANG OF ATTACK	-4.91 DEG	FLAP ITERATION	OFF
LAT FLAP ANGLE	-0.821 DEG	TWIST	-10.00 DEG	CNT PL ANG OF ATTACK	-9.70 DEG	FREQUENCY CHANGE	OFF
TOTAL FLAP ANGLE	1.810 DEG	TIP SWEEP	0.0 DEG	ROTOR TIP SPEED	746.6 FT/SEC	ELASTIC PYLON	OFF

* * * * * * FORCES AND MOMENTS * * * * * *

	WIND AXIS SYSTEM DIMENSIONLESS HELICOPTER	FIXED-WING	DIMENSIONAL		SHAFT AXIS SYSTEM DIMENSIONLESS HELICOPTER	FIXED-WING	DIMENSIONAL
LIFT FORCE	0.0669782	1.2313070	7358.74 LBS	THRUST	0.0671262	1.2340279	7375.00 LBS
DRAG FORCE	-0.0044773	-0.0823096	-491.91 LBS	H FORCE	-0.0006397	-0.0117599	-70.28 LBS
LAT FORCE	-0.0015829	-0.0290991	-173.91 LBS	Y FORCE	-0.0015166	-0.0278837	-166.64 LBS
ROLL MOMENT	-0.0002546	-0.0023460	-615.34 FT-LBS	ROLL MOMENT	0.0000000	0.0000000	0.00 FT-LBS
PITCH MOMENT	0.0000037	0.0000345	9.06 FT-LBS	PITCH MOMENT	-0.0000000	-0.0000006	-0.06 FT-LBS
YAW MOMENT	0.0044186	0.0406151	10680.14 FT-LBS	YAW MOMENT	0.0044259	0.0406825	10697.86 FT-LBS
				POWER	0.0044259	0.2783518	660.07 HP

* * * * * * ROTOR LOADS * * * * * *

R/R	BEAM LOADS (IN-LBS) MEAN	OSC	/MAX AZ	/MIN AZ	CHORD LOADS (IN-LBS) MEAN	OSC	/MAX AZ	/MIN AZ
0.0	-32405.44	8766.20	260.	30.	9.01	29759.52	330.	150.
0.02	-17046.47	4596.09	100.	40.	1554.02	28756.98	330.	150.
0.08	-8679.70	13214.68	330.	110.	7296.76	25991.18	330.	150.
0.14	-5649.38	16298.11	310.	110.	8536.41	22551.48	330.	150.
0.20	-2894.77	13582.62	310.	110.	9620.18	19969.24	330.	150.
0.25	-1249.21	9680.73	310.	100.	9680.26	17934.02	330.	150.
0.31	-376.13	6901.61	310.	100.	8947.30	15686.34	330.	150.
0.35	-253.36	5906.20	320.	90.	8726.59	14219.22	330.	150.
0.39	-577.51	5372.92	320.	80.	8407.23	12888.58	330.	150.
0.45	-1326.12	4943.30	320.	80.	7727.26	11013.62	330.	150.
0.50	-2058.03	4785.93	240.	80.	7060.70	9561.79	330.	150.
0.55	-2817.11	5262.32	250.	80.	6144.52	8217.93	330.	150.
0.59	-3483.36	5983.79	250.	80.	5352.68	7244.05	330.	150.
0.65	-4197.40	6837.65	260.	80.	4112.62	5844.14	330.	150.
0.70	-4515.15	7077.80	260.	150.	3063.42	4736.71	330.	150.
0.75	-4637.07	6976.55	260.	150.	2072.53	3679.37	330.	150.
0.80	-4132.49	6625.03	260.	150.	1148.75	2594.04	330.	90.
0.85	-3266.27	4695.88	260.	150.	548.79	1753.34	330.	90.
0.90	-1840.40	2591.40	260.	150.	161.24	875.84	330.	90.
0.95	-615.11	826.06	260.	150.	18.16	275.44	330.	90.
1.00	0.0	0.0	0.	0.	0.0	0.0	0.	0.

R/R	TORSION LOADS (IN-LBS) MEAN	OSC	/MAX AZ	/MIN AZ
0.0	0.0	0.0	0.	0.
0.02	0.0	0.0	0.	0.
0.08	-3885.15	5875.31	270.	110.
0.14	-3654.18	4503.30	270.	120.
0.20	-3834.64	3894.43	270.	140.
0.25	-3961.89	3694.22	270.	150.
0.31	-3980.69	3620.01	270.	150.
0.35	-4037.76	3474.44	270.	150.
0.39	-4097.54	3311.28	270.	150.
0.45	-4220.37	3040.32	270.	150.
0.50	-4301.76	2712.18	270.	160.
0.55	-4363.45	2569.56	280.	210.
0.59	-4418.98	2489.21	280.	210.
0.65	-4436.65	2407.33	70.	210.
0.70	-4163.47	2326.05	70.	200.
0.75	-3949.34	2183.34	70.	200.
0.80	-3642.86	1952.38	60.	170.
0.85	-3049.09	1696.39	280.	160.
0.90	-2298.76	1338.22	280.	160.
0.95	-1294.24	781.38	280.	160.
1.00	0.0	0.0	0.	0.

Figure 56. Optional Trim Page.

the dimensional forces, moments, and power are divided by to give their nondimensional forms are given below:

	Forces	Moments	Power
Helicopter	$\rho bcR(\Omega R)^2$	$\rho bcR(\Omega R)^2 R$	$\rho bcR(\Omega R)^3$
Fixed Wing	$qD^2\sigma$	$qD^3\sigma$	$qD^2\sigma V$

where

ρ = air density (slugs/ft^3)

b = number of blades

c = chord (ft)

R = rotor radius (ft)

Ω = rotor speed (rad/sec)

V = wind velocity (ft/sec)

q = $1/2\ \rho\ V^2$ (lbf/ft^2)

D = diameter of rotor disk = 2R (ft)

σ = rotor solidity = $bcR/\pi R^2$

6.5.2.4 Rotor Loads

If rotor blade elastic mode shapes have been included in the analysis, a summary of the beam, chord, and torsional rotor loads is printed below the forces and moments. Data are presented for all blade stations. The higher the station number or percent radius, the more outboard the station is. The data for each of the three loads consists of the mean and oscillatory values plus blade azimuth location for the maximum and minimum loads. The loads are in inch-pounds; the azimuth angles are in degrees.

6.6 TIME-VARIANT TRIM DATA

Using appropriate input values, it is possible to compute the trimmed flight condition using only a quasi-static rotor analysis, or to compute first a trim with the quasi-static analysis and follow it with a time-variant trim (TVT) of the rotor. The output of the TVT following a quasi-static trim is discussed below.

6.6.1 The Time History (Figure 57)

Following the quasi-static trim, the program computes a time history of XIT(6) revolutions for each rotor for which the time-variant analysis is to be used. During the computations, the fuselage and flight control degrees of freedom are locked out

***** START OF MRTV ITERATION 1 *****

DEPENDENT PARTICIPATION FACTORS

REF TIME PCT	1 11 P9	2 P1 P10	3 P2 PDDX/G	4 P3 PDDY/G	5 P4 PDDZ/G	6 P5	7 P6	8 P7	9
[illegible]	.6459?	.20569E-01	.29637E-02	.57388E-02	-.69413E-03	-.39203	-.19229E-01	-.10550E-01	-.12090E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
7.[illegible]	.678[illegible]	.12154E-01	.73699E-03	-.21854E-02	-.12903E-02	-.39651	-.19154E-01	-.10050E-01	-.12539E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
15.[illegible]	.6983[illegible]	.35506E-02	-.15169E-02	-.98196E-02	-.19666E-02	-.38488	-.18850E-01	-.81614E-02	-.13952E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
[illegible]	.70661	-.51567E-02	-.37527E-02	-.17010E-01	-.26312E-02	-.37631	-.18353E-01	-.50367E-02	-.15489E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
[illegible]	.70247	-.13944E-01	-.59735E-02	-.23853E-01	-.31821E-02	-.36643	-.17773E-01	-.16735E-02	-.16273E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
38.[illegible]	.65350	-.22789E-01	-.81525E-02	-.30646E-01	-.35572E-02	-.35689	-.17244E-01	.89094E-03	-.15744E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
45.957	.65552	-.31606E-01	-.10245E-01	-.37686E-01	-.37546E-02	-.34965	-.16867E-01	.16649E-02	-.13834E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
53.617	.61280	-.40195E-01	-.12179E-01	-.45015E-01	-.38092E-02	-.34377	-.16685E-01	.42000E-03	-.10958E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
61.277	.55851	-.48265E-01	-.13886E-01	-.52217E-01	-.37734E-02	-.34127	-.16706E-01	-.34623E-02	-.78863E-02
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
68.936	.49405	-.5531[illegible]E-01	-.15323E-01	-.58441E-01	-.37641E-02	-.34129	-.16911E-01	-.82644E-02	-.54839E-02
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
76.596	.42129	-.61634E-01	-.16481E-01	-.62650E-01	-.36355E-02	-.34348	-.17335E-01	-.13051E-01	-.44726E-02
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
84.255	.34192	-.6641[illegible]E-01	-.17353E-01	-.64073E-01	-.35787E-02	-.34772	-.17976E-01	-.16748E-01	-.51221E-02
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
91.915	.25717	-.69649E-01	-.17869E-01	-.62587E-01	-.35169E-02	-.35431	-.18782E-01	-.18851E-01	-.71657E-02
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
99.574	.16794	-.71299E-01	-.17996E-01	-.58784E-01	-.34350E-02	-.36384	-.19636E-01	-.19527E-01	-.98953E-02
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
107.23	.751[illegible]7E-01	-.71343E-01	-.17573E-01	-.53721E-01	-.33533E-02	-.37670	-.20405E-01	-.19341E-01	-.12461E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
114.89	-.201[illegible]4E-01	-.69861E-01	-.16649E-01	-.48452E-01	-.33933E-02	-.39273	-.21015E-01	-.18662E-01	-.14209E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
122.55	-.116[illegible]4	-.67013E-01	-.15337E-01	-.43868E-01	-.36401E-02	-.41104	-.21473E-01	-.18352E-01	-.14872E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
13[illegible]	-.21048	-.62991E-01	-.13815E-01	-.40131E-01	-.40435E-02	-.43025	-.21841E-01	-.17734E-01	-.14592E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0	.0	.0	.0				
137.87	-.[illegible]0114	-.57974E-01	-.12241E-01	-.37112E-01	-.43775E-02	-.44883	-.22179E-01	-.16805E-01	-.13788E-01
	.0	.0	.0	.0	.0	.0	.0	.0	
	.0	.0			.0				
145.53	-.38576	-.52117E-			[illegible]74E-02	-.46548	-.22516E-01	-.15397E-01	-.12989E-01
	.0					.0	.0	.0	
153.19	-.44[illegible]						-.22828E-01	-.13509E-01	-.12656E-01
							.0	.0	
16[illegible]							[illegible]	-.11292E-01	-.13058E-0[illegible]

Figure 57. Partial Printout of Time-Variant Trim Data.

and the orientation and control positions are held fixed at the values in the quasistatic trim condition. However, all rotor and pylon modes which are input are free. The output of a TVT includes the complete time history for each time-variant rotor and elastic pylon (if activated).

The time history is printed in columnar form with the variables identified only at the beginning. The azimuth location in degrees of Blade No. 1 is the column headed REF BLADE PSI. If the rotor(s) use the elastic blade representation, up to 11 modal participation factors are listed under DEPENDENT PARTICIPATION FACTORS, depending on the number of mode shapes input for that rotor. If a rigid blade is used, only the first factor is nonzero. Up to 10 more participation factors are printed out for the Rotor 1 rotor pylon modes. If two elastic rotors are being used, the time history for the second rotor follows immediately after the first. A new set of headings is printed before the Rotor 2 time history.

A time history of rotor blade displacement or bending moment at the j^{th} station ($D_j(t)$ or $BM_j(t)$) can be computed from the participation factors for the last rotor revolution. Multiply the participation factor for the i^{th} mode, $\delta_i(t)$, by either the displacement or bending moment coefficient of the i^{th} mode at the j^{th} station (MS_{ij} or BMC_{ij}) and sum over all modes to get the value at that time-point, i.e.,

$$D_j(t) = \sum_{i=1}^{NMODES} \delta_i(t) MS_j$$

$$BM_j(t) = \sum_{i=1}^{NMODES} \delta_i(t) BMC_j$$

Note that the bending moment coefficients are in the inplane/out-of-plane coordinate system, not beam-chord.

6.6.2 Revised Trim Data

At the end of the time-history printout(s), the VAR(I) values, rotor performance data, and force and moment summary (see Sections 6.4.1, 6.4.2, and 6.4.3 respectively) are printed again for comparison to the quasi-static trim values. Note that the rotor flapping angles are not printed with VAR(I) since they are not independent variables. In addition to the normal force and moment summary, the rotor flapping moment

about the hub is printed at the end of the summary. The standard trim page is then printed again, this time with the rotor parameters reset to the values at the end of the time-variant trim.

6.6.3 Rotor Dynamic Analysis

A harmonic analysis of the time history is performed, and a rotor bending moment summary is printed after the Revised Trim Page.

6.6.3.1 Harmonic Analysis of Elastic Rotor Parameters (Figure 58)

The results of a harmonic analysis of the time histories, shown in Figure 58, are printed in tabular form. From left to right, the nine columns of data are the coefficients for the zero (constant) through eighth rotor harmonic. The printout of all cosine components precedes that of the sine components. The rows labeled 1 through IPL(6) (or IPL(7) for Rotor 2) are the harmonics of the rotor modal participation factors, while the remaining rows are for the pylon modes.

The harmonic content of the blade displacements can be determined from the harmonic content of the participation factors by using the following equation:

$$D_{cos_{n,j}} = \sum_{i=1}^{NMODES} \delta_{cos_{n,i}} MS_{ij}$$

$$D_{sin_{n,j}} = \sum_{i=1}^{NMODES} \delta_{sin_{n,i}} MS_{ij}$$

where $D_{cos_{n,j}}$ = n^{th} harmonic cosine component of displacement at the j^{th} station

$D_{sin_{n,j}}$ = n^{th} harmonic sine component of displacement at the j^{th} station

$\delta_{cos_{n,i}}$ = n^{th} harmonic cosine component of the participation factor of the i^{th} mode

$\delta_{sin_{n,i}}$ = n^{th} harmonic sine component of the participation factor of the i^{th} mode

HARMONIC ANALYSIS OF ROTOR 1

COSINE COMPONENTS

1	.876566E-05	.664080	.373734E-04	.794402E-02	.837255E-05	-.102267E-02	.290166E-05	.122386E-03	.341141E-05
2	.162327E-04	.160788E-01	-.848518E-04	-.102096E-03	-.109054E-04	.142988E-05	-.544891E-05	-.166547E-04	-.358506E-05
3	-.243491E-06	.271464E-02	.322633E-05	-.101674E-02	.100414E-05	.249638E-03	.305266E-06	-.345092E-04	-.107122E-06
4	-.551914E-05	.545854E-02	.104784E-05	.519715E-02	.188912E-05	-.706181E-03	-.145301E-05	.173166E-03	.343995E-07
5	-.485993E-06	-.896169E-03	.580055E-06	.589526E-03	-.505936E-06	-.106947E-02	.767925E-06	.280989E-04	-.216364E-06
6	-.399414	-.669779E-04	-.520362E-01	.149747E-04	.163353E-02	-.226498E-05	-.501412E-03	.210519E-06	-.210519E-06
7	-.196377E-01	-.169334E-05	-.433455E-02	-.151548E-05	-.776594E-03	.316570E-06	.464567E-05	-.327508E-06	.175659E-05
8	-.107710E-01	-.213150E-05	.557676E-02	.651070E-05	-.291454E-02	-.155146E-05	.124496E-03	.223834E-06	.906355E-05
9	-.120720E-01	-.941369E-06	-.395377E-02	.165149E-05	.226421E-02	.396260E-05	.442598E-03	-.442279E-07	.175437E-05
10	.0	.0	.0	.0	.0	.0	.0	.0	.0
11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12	.0	.0	.0	.0	.0	.0	.0	.0	.0
13	.0	.0	.0	.0	.0	.0	.0	.0	.0
14	.0	.0	.0	.0	.0	.0	.0	.0	.0
15	.0	.0	.0	.0	.0	.0	.0	.0	.0
16	.0	.0	.0	.0	.0	.0	.0	.0	.0
17	.0	.0	.0	.0	.0	.0	.0	.0	.0
18	.0	.0	.0	.0	.0	.0	.0	.0	.0
19	.0	.0	.0	.0	.0	.0	.0	.0	.0
20	.0	.0	.0	.0	.0	.0	.0	.0	.0
21	.0	.0	.0	.0	.0	.0	.0	.0	.0

SINE COMPONENTS

1	.0	.304679	.196264E-04	-.100632E-01	.183235E-04	-.423233E-04	.770119E-05	-.117061E-03	.629912E-05
2	.0	-.644742E-01	-.188400E-04	.836044E-03	-.617592E-05	-.160498E-03	-.378382E-05	-.322804E-04	-.261351E-05
3	.0	-.169367E-01	.241193E-06	.229725E-02	-.965284E-06	-.203010E-03	.197333E-06	-.118493E-04	-.143567E-07
4	.0	-.596167E-01	-.736603E-06	-.905185E-03	.776594E-06	-.115710E-02	-.106646E-05	-.207521E-04	-.313665E-06
5	.0	-.433823E-02	-.793477E-06	-.213089E-02	.441697E-05	-.266632E-02	.192803E-06	.427558E-04	.610467E-07
6	.0	-.563060E-05	-.181023E-01	.484787E-05	.242228E-02	.211265E-05	-.562946E-03	-.193169E-05	.360509E-04
7	.0	-.793775E-06	.421245E-02	-.574100E-05	-.791039E-03	-.952578E-06	.323796E-04	-.443997E-06	-.152680E-04
8	.0	-.885918E-06	.813311E-02	-.402776E-05	.392903E-04	.105102E-05	-.761367E-03	-.817929E-06	.244595E-04
9	.0	.425137E-06	.274685E-03	.214196E-05	.276320E-03	-.918389E-05	-.460532E-03	.433149E-06	-.385064E-04
10	.0	.0	.0	.0	.0	.0	.0	.0	.0
11	.0	.0	.0	.0	.0	.0	.0	.0	.0
12	.0	.0	.0	.0	.0	.0	.0	.0	.0
13	.0	.0	.0	.0	.0	.0	.0	.0	.0
14	.0	.0	.0	.0	.0	.0	.0	.0	.0
15	.0	.0	.0	.0	.0	.0	.0	.0	.0
16	.0	.0	.0	.0	.0	.0	.0	.0	.0
17	.0	.0	.0	.0	.0	.0	.0	.0	.0
18	.0	.0	.0	.0	.0	.0	.0	.0	.0
19	.0	.0	.0	.0	.0	.0	.0	.0	.0
20	.0	.0	.0	.0	.0	.0	.0	.0	.0
21	.0	.0	.0	.0	.0	.0	.0	.0	.0

SHEARS AND MOMENTS AT TOP OF MAST IN SHAFT REFERENCE FOR ROTOR 1

X SHEAR		Y SHEAR		Z SHEAR		PITCH MOMENT		ROLL MOMENT	
COS	SIN	COS	SIN	COS	SIN	COS	SIN	COS	SIN
231.557	0.0	-249.435	0.0	-6080.891	0.0	-0.000	0.0	0.000	0.0
0.186	-0.186	-0.269	0.017	0.073	-0.006	-0.000	-0.002	0.002	0.000
-126.250	93.038	124.869	138.669	1381.719	553.264	-0.000	-0.000	0.000	0.000
-0.058	1.640	0.914	0.130	0.612	-0.378	0.000	-0.000	0.000	0.000
-10.415	-21.157	-9.546	12.077	-386.101	-41.374	0.000	0.000	-0.000	0.000
0.643	0.229	0.158	0.071	-0.465	0.965	0.000	0.000	-0.000	0.000
0.336	-2.340	-4.196	-0.967	-32.718	11.998	-0.000	0.000	-0.000	-0.000
0.053	0.116	0.068	0.018	0.039	-0.068	-0.000	0.000	0.000	-0.000
-0.296	0.813	1.321	0.548	0.284	5.085	-0.000	0.000	0.000	-0.000

Figure 58. Harmonic Analysis Following Time-Variant Trim.

$MS_{i,j}$ = modal displacement of the i^{th} mode at the j^{th} station

NMODES = number of modes

Note that the modal displacements are in the inplane/out-of-plane coordinate system, not beam-chord.

The tabulation of the participation factor harmonics is followed by a tabulation of the nonrotating hub shears and moments, giving the steady through 8-per-rev sin ωt and cos ωt components. The units are either pounds or foot-pounds.

If elastic pylon modes were included, a similar tabulation of fixed system hub vibrations follows. AMP is the square root of the sum of the squares of the sine and cosine components. The vibrations are in g's.

If the Rotor 1 pylon was represented by elastic modes, a tabulation of accelerations at a specified point is printed after the hub vibrations.

6.6.3.2 Rotor Bending Moment Summary for Elastic Rotor (Figure 59)

A seven-page listing of rotor bending moments in blade reference is printed for each time-variant rotor following the harmonic analysis. Tables of the beam, chord, and torsional moments for the first eight rotor harmonics and at all radial stations are shown on the first six pages. A summary of the minimum, maximum, and oscillatory moments, with azimuth locations for the extreme values, is printed on the seventh page. The oscillatory moment is defined as one-half the difference of maximum and minimum, regardless of frequency considerations. All moments are in inch-pounds.

6.7 MANEUVER-TIME-POINT PRINTOUT (Figure 60)

It is possible to print out data computed during a maneuver at specified time points. The value of NPRINT on CARD 01 specifies that data is to be printed each NPRINTth time point.

6.7.1 External Store Drop Printout

A message is printed stating which store was dropped whenever an external store is jettisoned during the maneuver. Also, the values for the gross weight, cg location, and inertias of the rotorcraft following the drop are printed. If two or more stores are dropped simultaneously, independent messages are printed for each drop. The printout precedes the printout of the first time point without the store(s).

ROTOR NUMBER 1 BEAM BENDING MOMENTS INCH-POUNDS

SINE COMPONENTS

STATION / HARMONIC	STEADY	1/REV	2/REV	3/REV	4/REV	5/REV	6/REV	7/REV	8/REV
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	-750.44	88.66	-170.97	29.19	-126.54	-37.24	1.73	-0.72
18	0.0	-2324.65	290.56	-411.03	62.67	-358.51	-99.83	4.96	-2.82
17	0.0	-4211.00	531.23	-648.78	90.43	-612.36	-166.84	8.86	-5.41
16	0.0	-5456.16	672.75	-808.57	108.21	-766.07	-268.17	11.86	-6.67
15	0.0	-6425.62	769.81	-862.48	104.25	-822.84	-226.44	14.35	-7.26
14	0.0	-6710.55	761.64	-849.55	93.66	-776.84	-219.04	15.72	-6.25
13	0.0	-6595.38	685.25	-865.85	81.61	-666.83	-197.79	16.46	-4.20
12	0.0	-5848.55	449.61	-709.55	66.37	-452.91	-154.46	16.39	-0.57
11	0.0	-5149.87	320.11	-651.39	57.35	-295.82	-120.76	16.24	2.24
10	0.0	-4582.81	150.12	-554.30	42.24	-105.23	-82.26	15.61	5.43
9	0.0	-4472.86	45.02	-430.16	15.84	74.81	-44.30	14.60	8.48
8	0.0	-4584.42	-65.00	-241.36	-23.47	310.14	4.57	12.51	12.19
7	0.0	-4934.03	-117.39	-103.05	-59.17	469.74	40.93	10.68	14.69
6	0.0	-5717.83	-129.97	113.72	-110.98	666.27	84.49	7.70	17.26
5	0.0	-7853.21	-74.82	550.28	-212.67	1042.11	163.57	0.96	21.93
4	0.0	-10988.65	64.04	1043.04	-337.79	1461.49	254.24	-7.47	27.24
3	0.0	-13224.22	-169.06	1372.16	-424.31	1678.95	316.81	-13.28	27.16
2	0.0	-13646.21	-1192.84	668.28	-284.37	979.61	221.53	-4.10	11.44
1	0.0	69.32	-2308.29	-76.61	303.10	244.72	-57.66	-3.81	-6.56
0	0.0	0.0	-3812.26	3.09	408.98	-4.68	-91.69	0.31	-21.27

COSINE COMPONENTS

STATION / HARMONIC	STEADY	1/REV	2/REV	3/REV	4/REV	5/REV	6/REV	7/REV	8/REV
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	-580.81	65.26	7.86	151.32	47.51	-65.01	19.40	5.62	0.41
18	-1894.47	162.26	-126.79	361.22	149.93	-173.34	56.25	13.91	1.14
17	-3480.26	277.71	-334.68	571.56	263.85	-289.53	96.16	22.86	2.03
16	-4443.49	382.55	-425.54	720.66	316.07	-362.92	117.14	29.55	2.70
15	-5092.25	477.11	-566.81	790.31	319.67	-396.85	122.30	33.92	3.48
14	-5012.04	555.36	-425.35	810.55	252.03	-388.36	107.17	36.31	4.00
13	-4497.23	628.81	-232.99	813.25	139.91	-356.46	79.68	37.91	4.47
12	-3333.74	687.55	116.44	766.26	-37.80	-286.83	32.10	38.41	4.93
11	-2380.07	729.16	389.82	760.32	-167.56	-236.21	-4.13	38.16	5.20
10	-1415.76	787.14	665.09	735.85	-329.07	-171.57	-46.99	37.99	5.59
9	-715.66	898.83	925.34	704.06	-505.22	-106.37	-89.93	37.25	6.00
8	-50.15	1077.45	1172.18	653.92	-731.26	-16.38	-143.88	35.52	6.45
7	226.69	1283.82	1299.45	602.56	-898.92	46.86	-182.96	33.21	6.66
6	187.89	1582.27	1349.75	522.42	-1094.70	131.81	-226.68	29.72	6.84
5	-485.79	2298.17	1364.75	383.65	-1475.69	297.14	-305.25	23.26	6.93
4	-1815.51	3356.36	1317.29	222.16	-1934.01	483.60	-394.98	15.12	6.76
3	-4840.90	4367.23	462.62	-55.41	-2021.80	598.53	-434.53	2.91	6.20
2	-13414.83	4444.60	-1969.65	-336.45	-907.07	331.68	-284.77	-7.95	5.06
1	-17645.95	-107.43	-3209.31	331.41	956.42	50.34	58.68	10.41	-0.71
0	-33483.91	-4.89	-7148.41	0.54	2053.55	2.21	153.15	-6.03	-1.61

a) Typical Bending Moment Printout.

Figure 59. Bending Moment Output Following Time-Variant Trim.

STATION / HARMONIC		STEADY	ROTOR NUMBER 1 1/REV	2/REV	3/REV	4/REV	5/REV	6/REV	7/REV	8/REV
20	AMPLITUDE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PHASE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	AMPLITUDE		753.31	89.01	228.32	55.76	142.26	41.99	5.88	0.83
	PHASE		-85.63	84.93	-48.49	31.57	-117.19	-62.49	17.16	-60.00
18	AMPLITUDE		2330.31	317.29	547.20	162.50	398.22	114.58	14.77	3.05
	PHASE		-86.01	113.55	-48.69	27.69	-115.80	-60.60	19.61	-68.03
17	AMPLITUDE		4220.15	627.87	814.64	278.92	77.36	192.57	24.46	5.78
	PHASE		-86.23	122.21	-46.62	18.92	-115.31	-60.04	21.24	-69.41
16	AMPLITUDE		5469.55	798.03	1083.08	334.08	842.27	238.86	31.84	7.22
	PHASE		-85.99	122.32	-48.29	19.90	-115.52	-60.63	21.88	-67.49
15	AMPLITUDE		6443.31	921.67	1169.81	336.44	913.54	257.36	36.84	8.05
	PHASE		-85.75	123.36	-47.50	18.05	-115.75	-61.63	22.93	-64.39
14	AMPLITUDE		6733.50	872.37	1174.19	268.87	868.51	241.85	39.57	7.42
	PHASE		-85.27	119.18	-46.35	20.39	-116.56	-63.93	23.41	-57.35
13	AMPLITUDE		6625.29	723.77	1144.89	161.98	756.12	213.23	41.32	6.13
	PHASE		-84.55	108.78	-44.74	30.26	-118.13	-68.06	23.47	-43.22
12	AMPLITUDE		5888.82	500.27	1059.04	76.38	536.10	157.76	41.76	4.96
	PHASE		-83.30	76.62	-42.07	119.66	-122.35	-78.26	23.11	-6.65
11	AMPLITUDE		5201.23	504.41	1001.20	177.11	378.55	120.83	41.47	5.64
	PHASE		-81.94	19.39	-40.59	161.11	-128.61	-91.96	23.66	22.91
10	AMPLITUDE		4649.92	701.35	921.26	331.77	231.27	94.74	41.07	7.79
	PHASE		-80.25	12.36	-36.99	172.69	-148.48	-119.73	22.53	44.18
9	AMPLITUDE		4562.27	926.44	525.06	505.47	130.04	120.25	40.01	10.39
	PHASE		-78.64	2.79	-31.42	178.20	144.88	-153.77	21.41	54.72
8	AMPLITUDE		4709.33	1173.98	697.02	731.64	310.57	143.95	37.66	13.79
	PHASE		-76.77	-3.17	-20.25	-178.16	93.02	178.18	19.39	62.12
7	AMPLITUDE		5103.16	1304.74	611.25	900.97	472.57	187.48	34.88	16.14
	PHASE		-75.43	-5.16	-9.71	-176.23	84.30	167.39	17.82	65.55
6	AMPLITUDE		5932.72	1355.99	534.65	1100.31	679.18	241.92	30.70	18.57
	PHASE		-74.53	-5.50	12.28	-174.21	78.81	159.56	14.52	68.38
5	AMPLITUDE		8182.58	1366.80	670.82	1490.93	1083.64	346.32	23.26	23.00
	PHASE		-73.69	-3.14	55.12	-171.80	74.09	151.82	2.36	72.47
4	AMPLITUDE		11489.79	1318.84	1066.43	1963.29	1539.24	469.73	16.86	28.67
	PHASE		-73.02	2.78	77.98	-170.09	71.71	147.23	-26.30	76.06
3	AMPLITUDE		13926.69	494.98	1373.22	2365.84	1752.44	537.76	13.60	27.86
	PHASE		-71.72	-12.73	92.31	-168.15	70.38	143.90	-77.66	77.14
2	AMPLITUDE		11813.92	2251.58	748.20	950.60	1034.24	360.79	8.95	12.52
	PHASE		-67.90	-148.01	116.72	-162.55	71.29	142.12	-152.70	66.05
1	AMPLITUDE		127.85	3953.21	340.15	1003.29	249.84	82.23	11.09	6.54
	PHASE		147.17	-144.27	-13.02	17.58	78.38	-44.47	-20.08	-96.20
[illegible]	AMPLITUDE		4.89	8101.42	3.14	2093.88	5.17	178.19	0.31	21.33
	PHASE		0.0	-151.93	80.13	11.26	-64.73	-30.74	95.91	-94.33

a) Concluded.

Figure 59. Continued.

ROTOR NUMBER 1 SUMMARY INCH POUNDS

STATION	FLAP BENDING MOMENT OSCILLATORY	MAXIMUM	AZ	MINIMUM	AZ	CHORD BENDING MOMENT OSCILLATORY	MAXIMUM	AZ	MINIMUM	AZ
	0.0	0.0	0.	0.0	0.	0.0	0.0	0.	0.0	0.
20	[illegible]	216.95	260.	-1441.17	150.	275.44	293.53	330.	-257.34	90.
19	2591.40	750.94	200.	-4431.87	150.	875.84	1037.09	330.	-714.60	90.
18	[illegible]	1435.01	260.	-7956.15	150.	1753.34	2302.13	330.	-1204.54	90.
17	[illegible]	[illegible]	260.	-10157.52	150.	2594.04	3742.79	330.	-1445.29	90.
16	[illegible]	[illegible]	260.	-11614.22	150.	3679.37	5751.90	330.	-1606.85	150.
15	[illegible]	[illegible]	260.	-11592.96	150.	4736.71	7800.12	330.	-1673.29	150.
14	7077.[illegible]	[illegible]	260.	-11035.05	80.	5844.14	9956.77	330.	-1731.52	150.
13	[illegible]	2640.25	260.	-9467.16	80.	7244.05	12596.74	330.	-1891.37	150.
12	[illegible]	[illegible]	250.	-8079.43	80.	8217.93	14362.45	330.	-2073.40	150.
11	5262.32	2445.[illegible]	250.	-6843.96	80.	9561.79	16502.56	330.	-2561.09	150.
10	[illegible]	2727.96	240.	-6269.42	80.	11013.62	18740.89	330.	-3286.35	150.
9	[illegible]	3617.17	320.	-5950.43	80.	12888.58	21295.81	330.	-4481.36	150.
8	5372.92	[illegible]	320.	-6159.56	90.	14219.22	22945.82	330.	-5492.63	150.
7	[illegible]	[illegible]	320.	-7277.94	100.	15686.34	24633.04	330.	-6739.04	150.
6	[illegible]	[illegible]	310.	-10929.94	100.	17934.02	27014.29	330.	-8853.77	150.
5	[illegible]	8431.52	310.	-16477.39	110.	19969.24	28989.43	330.	-10949.05	150.
4	[illegible]	10657.26	310.	-21947.49	110.	22551.48	31067.89	330.	-14615.07	150.
3	[illegible]	10640.73	310.	-21894.37	110.	25591.18	33287.95	330.	-18694.42	150.
2	13214.03	4534.98	300.	-21642.50	90.	28756.96	30311.00	330.	-27202.96	150.
1	[illegible]	-12450.30	100.	-41171.64	30.	29759.52	29768.53	330.	-29750.52	150.
0	[illegible]	[illegible]	280.							

STATION	TORSIONAL BENDING MOMENT OSCILLATORY	MAXIMUM	AZ	MINIMUM	AZ
	0.0	0.0	0.	0.0	0.
20	761.38	[illegible]	260.	-2075.62	160.
19	1339.22	[illegible]	280.	-3630.96	160.
18	1699.39	[illegible]	280.	-4739.48	160.
17	1952.38	[illegible]	60.	-5595.24	170.
16	[illegible]	[illegible]	70.	-6132.64	200.
15	2320.05	-1837.42	70.	-6489.53	200.
14	2407.32	-2029.52	70.	-6844.18	210.
13	2449.21	-1929.77	280.	-6908.20	210.
12	2569.56	-1793.89	280.	-6933.01	210.
11	2712.10	[illegible]	270.	-7113.95	160.
10	3040.32	-1186.06	270.	-7260.76	150.
9	3311.28	-780.26	270.	-7466.82	150.
8	3474.44	-563.33	270.	-7512.20	150.
7	[illegible]	[illegible]	270.	-7600.74	150.
6	[illegible]	-257.67	270.	-7650.12	150.
5	[illegible]	59.79	270.	-7729.08	140.
4	[illegible]	849.12	270.	-8157.48	120.
3	4503.30	1490.16	270.	-9760.46	110.
2	[illegible]	0.0	0.	0.0	0.
1	0.0	0.0	0.	0.0	0.
0	0.0	1053.86	110.	-115.35	270.
[illegible]	584.51				

b) Bending Moment Summary Page.

Figure 59. Concluded.

```
        0.373   SECONDS MANEUVER TIME                        0.872   MINUTES ELAPSED COMPUTING TIME

----WEIGHTS-----   CENTER OF GRAVITY (IN)       ------------POWER/TORQUE------------   ------------BLADE------------   -JET THRUST-
    POUNDS          S.L.      B.L.     W.L.                   SHAFT     TORQUE    SPEED     TIP    ADV BLD    INERTIA          LBS
BASIC A/C   8289.   196.70    0.0      74.88               HORSEPOWER   FT-LB      RPM     SPEED   MACH NO  SLUG-FT-SQ
STORES         0.                                   MAIN     740.18    11996.2    324.1    747.    0.884    1503.388     RT      0.0
TOTAL       8289.   196.70    0.0      74.88        TAIL      33.39      105.6   1656.6    737.    0.877       1.532     LT      0.0
                                                    ENG      773.56    12517.3   6600.0
                                                    REQD     773.56    12517.3

                                               BODY REFERENCE                                        GUSTS AT CG (FT/SEC)
                   U           V           W           P           Q           R        RDRWT          FWD      0.0
     VELOCITY   224.176      -2.058     -22.731      -0.145      -0.083       1.356       0.0          LAT      0.0
     ACCEL.       0.727      -5.476      -0.672      -4.136      -7.474       0.244       0.0          VERT     0.0

------FLIGHT PATH CONDITION-------     ------------------------AERODYNAMIC SURFACES---------------------------------------
TRUE AIRSPEED       (KNOTS)   133.51                ANGLE OF      FLAP      ------WIND AXIS COEF-------     AERODYNAMIC ANGLE
GROUND SPEED        (KNOTS)   133.51     SURFACE    INCIDENCE     ANGLE       CL        CD         CM       ATTACK   SIDESLIP
RATE OF CLIMB      (FT/SEC)    -0.26     NO. 1         4.50        0.0      0.2051    0.0165   -0.0019       5.18     -5.80
CLIMB ANGLE           (DEG)    -0.05     NO. 2         1.78        0.0     -0.1540    0.0155    0.0454      -4.55     -0.62
HEADING ANGLE         (DEG)    -0.01
ANGLE OF ATTACK       (DEG)    -5.79     NO. 3         1.78        0.0     -0.1548    0.0155    0.0455      -4.55     -0.62
ANGLE OF SIDESLIP     (DEG)    -0.53     NO. 4         0.0         0.0      0.0       0.0       0.0          0.0       0.0
ANGLE OF AERO YAW     (DEG)     0.52
ACCELERATIONS  VERT     (G)     1.19     RT WING      14.00        0.0      0.5354    0.0447    0.0          8.19     -0.20
               FWD      (G)     0.08     LT WING      14.00        0.0      0.5412    0.0453    0.0          8.25     -0.85
               LAT      (G)    -0.04

                                                        GROUND REFERENCE
                                 EULER ANGLES TO BODY  REFERENCE          DISPLACEMENTS
                                   PSI        THETA       PHI          X          Y           Z
                      VELOCITY    1.359      -0.015     -0.283     225.335     -0.020      0.263     DISTANCE      83.4
                      LOCATION    0.810      -5.808     -2.905      83.439     -0.012   -999.959     ALTITUDE    1000.0

CONTROL DISPLACEMENTS      ------------SWASH PLATE ANGLE (DEGREES)-------------      --HUB-MAST-PYLON---------(MAIN)---(TAIL)-
      ---PERCENT---        -------MAIN ROTOR-------    -------TAIL ROTOR-------      DELTA 3        (DEG)          0.0     45.0
                            COLL     F/A      LAT       COLL     F/A      LAT        PHASING        (DEG)          0.0      0.0
COLL      (UP)    41.60    16.04     0.0      0.0        0.0     0.0      0.0        HUB SPRING MOMENT F/A         0.       0.
F/A CYC  (FWD)    61.12     0.0      3.10     0.0        0.0     0.0      0.0                   (FT-LB) LAT        0.       0.
LAT CYC   (RT)    60.21     0.0      0.0     -0.84       0.0     0.0      0.0        PYLON ANGLES       F/A        0.0      0.0
PEDAL     (LT)    46.01     0.0      0.0      0.0       -2.96    0.0      0.0                     (DEG) LAT        0.0      0.0
SUM OF PYLON AND SCAS       0.0      0.0      0.0        0.0     0.0      0.0        MAST ANGLE (DEG)  F/A         0.0      0.0
TOTAL SWASH PLATE ANG      16.04     3.10    -0.84      -2.96    0.0      0.0                          LAT         0.0    -90.00

------------------------------------------------------------------------ROTORS--------------------------------------------------------
        BLADE FEATHERING - DEG       FLAPPING - DEG        FORCES (SHAFT AXIS) POUNDS        ADVANCE     CP        CT        INDUCED
        MEAN    PSI=0    PSI=90       F/A       LAT        THRUST    H-FORCE   Y-FORCE       RATIO     X10**5    X10**4     VELOCITY
MAIN    16.04    0.84    -3.10       0.254     0.361       9347.22    48.70    -240.41       0.300     31.399    53.825       6.00
TAIL    -2.96   -1.20     0.86      -1.203     0.857       -269.19    23.07      -1.83       0.366     39.405   -42.590      -6.19

                        BETA                               SHAFT AXIS DATA AT ROTOR HUB                   HUB MOTION (FT)           MAST
      PSI (DEG)     HUB      LIMIT        VELOCITIES (FT/SEC)              SHEAR FORCES (POUNDS)                                   WIND-UP
                   (DEG)     (DEG)       U          V         W          X         Y          Z           X        Y        Z       (DEG)
MAIN   360.00     -0.42     12.00     224.19     -2.08    -22.73     -408.7    -176.0    -4436.4        0.0      0.0      0.0       0.0
TAIL    80.65     -0.28     11.00     224.15    -22.77     -2.29      -24.5      -7.4      262.9        0.0      0.0      0.0       0.0
```

Figure 60. Maneuver-Time-Point Printout Page.

6.7.2 Time-Point Page

The format of and data on the maneuver-time-point page are identical to those of the standard trim page with the following exceptions. The problem identification data, trim condition specification, and atmospheric parameters are omitted; some data in the aerodynamic surfaces printout are changed; and some data are added at the top of the page, to the body and ground reference parameters, and to the rotor parameter printouts. The added data are discussed below.

6.7.2.1 Identification

The first line of the maneuver-time-point page contains the current time in the maneuver and the total elapsed computer CPU time.

6.7.2.2 Body Reference Data

In the body reference data printout, the three body linear accelerations in feet per second squared and the body angular accelerations in degrees per second squared are added to the printout. Also, the velocity and acceleration of the collective bobweight are included. Since the bobweight equation is written in terms of collective pitch angles, the parameters are angular velocity and acceleration in degrees per second and degrees per second squared, respectively.

6.7.2.3 Flightpath and Aerodynamic Surface Parameters

The printout of the flightpath and aerodynamic surface parameters is the same as on the standard trim page except that the body axis X, Y, and Z aerodynamic forces acting on the aerodynamic surface are changed to nondimensional lift, drag, and pitching moment coefficients in the wind axis reference system. The body axis X, Y, and Z forces are available from the force and moment summary which immediately follows the time-point page.

6.7.2.4 Ground Reference Parameters

The ground reference parameter printout is the same as on the standard trim page with the following data added: the X, Y, and Z displacement of the rotorcraft center of gravity from the origin of the ground reference system, the distance of the cg from the origin of the ground reference system as measured in the ground X-Y plane, and the geometric altitude of the cg (the negative of the ground reference Z-location). These additional data are in feet. Note that in the ground reference system, all maneuvers start with X = Y = 0 and Z = -(geometric altitude).

6.7.2.5 Flight and Rotor Control Parameters

The rotor parameters printout on the time-point page includes all data shown on the standard trim page plus additional rotor and mast data and the values of the gusts at the rotorcraft cg.

PSI (DEG) is the azimuth location of Blade No. 1 of each rotor. BETA refers to blade flapping at the hub with respect to the shaft reference X-Y plane. HUB is the flapping angle at the hub for Blade No. 1 at its present azimuth.

The forward, lateral, and vertical components of the gust velocities at the center of gravity are in body reference and have the units of feet per second.

6.7.3 Force and Moment Summary (Figure 61)

The maneuver-time-point page is followed by a force and moment summary for that time point, in the body axis coordinate system. If IPL(74) $\neq 0$, a wind-axis force and moment summary is also printed. The format of the summary is identical to the summary printed during trim iterations.

6.7.4 Rotor Elastic Response (Figure 61)

The azimuth location of each blade is given for reference. The instantaneous values of the generalized coordinates for each blade and each mode are available for detailed study. The three components of blade tip deflection provide the user with a clear indication of the overall rotor behavior. The out-of-plane and inplane deflections are in feet, and the elastic twist deflection is in degrees.

6.7.4.1 Blade Shear Forces

The out-of-plane components of shear are given for each blade in pounds. This shows how the blades share the total shear forces given above in the rotor variables.

6.7.4.2 Bending Moments at User-Selected Location

At one radial station selected by the user, IPL(77) or IPL(78), the computer program calculates and prints the beamwise bending moment, the chordwise bending moment, and the torsional moment for each blade in inch-pounds. The beam and chord moments have been resolved through the geometric pitch angle from the out-of-plane and inplane directions so that the values printed will be in the same coordinate system as test data.

FORCE AND MOMENT SUMMARY

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW	F/A MOM	LAT MOM
FUSELAGE	-401.2	120.6	130.0	17.1	-1978.1	312.9	-6472.5	0.2
MAIN ROTOR	-48.7	-240.4	-9347.2	-1560.3	-2254.5	66.1	-28.6	13.1
TAIL ROTOR	-23.1	269.2	-1.8	971.2	33.9	-7240.3		
RIGHT WING	-72.2	-21.6	-386.1	-906.1	184.5	159.2		
LEFT WING	-72.7	23.4	-390.2	914.9	186.7	-159.2		
STABILIZER #1	-13.8	201.6	3.5	373.9	113.8	-5119.2		
STABILIZER #2	0.6	0.1	66.9	94.6	1060.8	-3.0		
STABILIZER #3	0.7	0.1	61.3	-94.8	1066.7	-1.0		
GROSS WEIGHT	838.6	-418.0	8235.9					
M.R. TORQUE				0.0	0.0	11996.2		
T.R. TORQUE				0.0	-105.8	-0.6		
TOTAL	268.3	-64.9	-1633.9	-189.3	-1692.0	11.8		

**** MAIN ROTOR ****

VARIABLE	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
AZIMUTH	359.999	179.999	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 1	-0.097	0.097	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 2	0.022	-0.022	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 3	0.004	-0.004	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 4	0.003	-0.003	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 5	-0.001	0.001	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 6	-0.447	-0.447	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 7	-0.020	-0.020	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 8	0.008	0.008	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 9	-0.013	-0.013	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEN.COORD.MODE 11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIP DEFL.OUT-OF-PLANE	-0.562	-0.385	0.0	0.0	0.0	0.0	0.0
TIP DEFL.INPLANE	0.014	-0.024	0.0	0.0	0.0	0.0	0.0
TIP TWIST DEFL.	-1.125	-2.167	0.0	0.0	0.0	0.0	0.0
VERTICAL SHEAR AT HUB	1596.551	2838.976	0.0	0.0	0.0	0.0	0.0
INPLANE SHEAR AT HUB	-117.916	-293.889	0.0	0.0	0.0	0.0	0.0
LOADS AT R = 0.0 IN							
BEAM BENDING MOMENT	-42437.520	-42437.520	0.0	0.0	0.0	0.0	0.0
CHORD BENDING MOMENT	19812.75[illegible]	-19812.816	0.0	0.0	0.0	0.0	0.0
TORSIONAL MOMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 61. Maneuver-Time-Point Force and Moment Summary and Rotor Elastic Response Printout.

6.8 OUTPUT OF ROTORCRAFT STABILITY ANALYSIS ROUTINE (STAB)

The operation of the rotorcraft stability analysis routine (STAB) depends on the numerical evaluation of a number of partial derivatives that appear in the perturbation equations for rotorcraft motion. A frequency analysis is made on the equations of motion with controls fixed and following step inputs to the controls. As used here, "s" is the Laplace operator.

6.8.1 Control Partial Derivative Matrices (Figure 62)

6.8.1.1 Force and Moment Derivatives

The first version of the control partial derivative matrix is printed with units of pounds per inch or foot-pounds per inch. The response to each of the 14 degrees of freedom available in STAB is evaluated and ratioed to be the response to a 1-inch step input from each of the four controls. The rotor flapping angles are changed to reduce the rotor flapping moments to less than the allowable error if the rotor degrees of freedom are not turned on.

6.8.1.2 Control Derivatives in Terms of Accelerations

The second version of the control partial derivative matrix contains the same information as the first. In this matrix, the force and moment derivatives have been divided by the appropriate masses or inertias to give the units of linear or angular acceleration per inch of control. These numbers may be thought of as the accelerations at the instant immediately after a step input from the controls. The same labels are used for the rows of the second matrix as for the first.

6.8.1.3 Conventional Fixed-Wing Nondimensional Derivatives

If the rotorcraft does not have a wing or if the airspeed is less than 1.0 knots, this matrix is not printed. The reader is referred to Etkin, Reference 6, for the nondimensionalizing factors and for interpretation of the first six rows of the third matrix. No attempt will be made to interpret or explain the last eight rows of this matrix because conventional fixed-wing concepts do not apply to helicopter rotors and pylons.

6.8.2 Partial Derivatives for Rotorcraft Stability Analysis Degrees of Freedom

The next pages of output contain detailed information used for the calculation of the partial derivatives for each degree of freedom that is activated in STAB. The partial derivatives are evaluated in the same order in which the variables are listed below. See Figure 63.

CONTROL PARTIAL DERIVATIVE MATRICES

POUNDS/INCH OR FOOT-POUNDS/INCH

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	123.7	30.92	-29.20	-19.90
Y-FORCE	-136.1	116.0	117.1	517.4
Z-FORCE	-5248.	2935.	36.57	-4.571
YAW MOM	3385.	1867.	-898.4	-.1378E+05
PITCH MOM	-611.6	-956.2	204.4	-114.9
ROLL MOM	-961.5	818.9	826.9	2162.
M.R. F/A FLAP MOM	762.5	-91.26	-.2827E+05	-.8169
M.R. LAT FLAP MOM	.3569E+05	-.5834E+05	-39.27	-1.342
T.R. F/A FLAP MOM	.0	.0	.0	30.91
T.R. LAT FLAP MOM	.0	.0	.0	-522.6

FT/SEC**2 OR RAD/SEC**2 PER INCH

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	.4785	.1196	-.1129	-.7694E-01
Y-FORCE	-.5264	.4486	.4527	2.001
Z-FORCE	-20.30	11.35	.1414	-.1768E-01
YAW MOM	.3307	.1824	-.8779E-01	-1.346
PITCH MOM	-.5146E-01	-.8047E-01	.1720E-01	-.9668E-02
ROLL MOM	-.3311	.2820	.2847	.7446
M.R. F/A FLAP MOM	.5072	-.6070E-01	-18.81	-.5434E-03
M.R. LAT FLAP MOM	23.74	-38.81	-.2612E-01	-.8926E-03
T.R. F/A FLAP MOM	.0	.0	.0	20.17
T.R. LAT FLAP MOM	.0	.0	.0	-341.1

CONVENTIONAL FIXED WING NON-DIMENSIONAL DERIVATIVES

	COLLECTIVE	F/A CYCLIC	LAT CYCLIC	PEDAL
X-FORCE	.8989E-01	.2246E-01	-.2121E-01	-.1445E-01
Y-FORCE	-.9888E-01	.8427E-01	.8504E-01	.3759
Z-FORCE	-3.813	2.132	.2657E-01	-.3320E-02
YAW MOM	.2359	.1301	-.6261E-01	-.9602
PITCH MOM	-.1645	-.2572	.5499E-01	-.3091E-01
ROLL MOM	-.6700E-01	.5707E-01	.5762E-01	.1507
M.R. F/A FLAP MOM	.2051	-.2455E-01	-7.605	-.2197E-03
M.R. LAT FLAP MOM	2.487	-4.066	-.2736E-02	-.9352E-04
T.R. F/A FLAP MOM	.0	.0	.0	.8314E-02
T.R. LAT FLAP MOM	.0	.0	.0	-.3642E-01

Figure 62. Control Partial Derivative Matrix from STAB.

FUS. U = 222.85382 FUS. W = -12.41049 FUS. Q = 0.0 FUS. V = 3.33842 FUS. P = 0.0 FUS. R = 0.0
M.R. F/A FLAP RATE = 0.0 M.R. LAT FLAP RATE = 0.0 T.R. F/A FLAP RATE = 0.0 T.R. LAT FLAP RATE = 0.0
M.R. F/A FLAP DISP = -1.8370 M.R. LAT FLAP DISP = -0.5825 T.R. F/A FLAP DISP = -1.1840 T.R. LAT FLAP DISP = 1.0919

	THRUST	H-FORCE	Y-FORCE	TORQUE	IND. V.	JET THRUST	
MAIN ROTOR	7425.	-70.	-182.	11238.	6.159	RIGHT/CENTER	0.
TAIL ROTOR	-271.	19.	-4.	94.	-5.958	LEFT	0.

FORCE AND MOMENT SUMMARY

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW	F/A MOM	LAT MOM
FUSELAGE	-392.7	-32.1	72.2	-155.7	-1243.0	-834.2		
MAIN ROTOR	69.6	-182.4	-7425.0	-1288.4	-120.2	-9.1	-47.3	1351.0
TAIL ROTOR	-18.6	271.3	-4.0	1131.9	-29.7	-7215.4	-3.5	-7.7
RIGHT WING	-79.2	-31.4	-507.9	-1208.3	461.9	159.7		
LEFT WING	-78.7	26.6	-500.6	1190.8	455.3	-162.9		
STABILIZER #1	-13.6	131.5	1.1	319.3	60.9	-3298.1		
STABILIZER #2	-2.2	-0.1	16.9	25.6	314.3	4.3		
STABILIZER #3	-2.2	-0.1	16.7	-26.5	312.0	-2.5		
GROSS WEIGHT	475.8	-178.6	8303.5					
M.R. TORQUE				0.0	-0.0	11238.4		
T.R. TORQUE				0.0	-93.5	-0.0		
TOTAL	-41.7	4.8	-27.1	-11.2	118.1	-119.8		

DELTA

FORCE AND MOMENT SUMMARY

BODY AXIS	X-FORCE	Y-FORCE	Z-FORCE	ROLL	PITCH	YAW	F/A MOM	LAT MOM
FUSELAGE	-17.4	1.2	1.7	-7.4	-41.3	-20.5		
MAIN ROTOR	-15.3	-2.9	20.5	-20.8	106.9	-0.1	-47.3	1351.0
TAIL ROTOR	-0.8	0.4	0.1	1.7	6.6	-9.0	-3.5	-7.7
RIGHT WING	-3.7	-1.6	-25.9	-61.6	23.6	7.3		
LEFT WING	-3.6	1.4	-25.7	61.2	23.4	-7.4		
STABILIZER #1	-0.6	6.3	0.0	15.3	2.2	-158.4		
STABILIZER #2	-0.2	-0.0	-0.1	-0.2	-0.2	0.2		
STABILIZER #3	-0.2	-0.0	-0.1	0.2	-0.2	-0.2		
GROSS WEIGHT	0.0	0.0	0.0					
M.R. TORQUE				0.0	0.0	69.2		
T.R. TORQUE				0.0	-3.2	-0.0		
TOTAL	-41.7	4.7	-29.5	-11.6	117.8	-119.0		

Figure 63. Example of Partial Derivative for STAB Degrees of Freedom.

6.8.2.1 Rotorcraft Stability Analysis Degrees of Freedom

At the top of each partial derivative page is a list of the current values of each of the possible degrees of freedom. All FUS (fuselage) parameters are in the body reference system and all M.R. and T.R. (rotor) parameters are in the appropriate shaft reference system. By a comparison of two successive pages, it is possible to tell which variable is being perturbed and by how much.

The 30 variables which may be perturbed are perturbed in the following order:

FUS. U = velocity in the X direction (ft/sec)

FUS. W = velocity in the Z direction (ft/sec)

FUS. Q = pitch rate (deg/sec)

FUS. V = velocity in the Y direction (ft/sec)

FUS. P = roll rate (deg/sec)

FUS. R = yaw rate (deg/sec)

M.R. PYLON MODE 1 RATE = (deg/sec)

M.R. PYLON MODE 2 RATE = (deg/sec)

M.R. PYLON MODE 3 RATE = (deg/sec)

M.R. PYLON MODE 4 RATE = (deg/sec)

T.R. PYLON MODE 1 RATE = (deg/sec)

T.R. PYLON MODE 2 RATE = (deg/sec)

T.R. PYLON MODE 3 RATE = (deg/sec)

T.R. PYLON MODE 4 RATE = (deg/sec)

M.R. F/A FLAP. RATE = (deg/sec)

M.R. LAT FLAP. RATE = (deg/sec)

T.R. F/A FLAP. RATE = (deg/sec)

T.R. LAT FLAP. RATE = (deg/sec)

M.R. PYLON MODE 1 DISP = (deg)

M.R. PYLON MODE 2 DISP = (deg)

M.R. PYLON MODE 3 DISP = (deg)

M.R. PYLON MODE 4 DISP = (deg)

T.R. PYLON MODE 1 DISP = (deg)

T.R. PYLON MODE 2 DISP = (deg)

T.R. PYLON MODE 3 DISP = (deg)

T.R. PYLON MODE 4 DISP = (deg)

M.R. F/A FLAP. DISP = (deg)

M.R. LAT FLAP. DISP = (deg)

T.R. F/A FLAP. DISP = (deg)

T.R. LAT FLAP. DISP = (deg)

Note that only the displacements of the first four Rotor 1 pylon modes can be varied during STAB.

6.8.2.2 Rotor Performance

These two rows are identical to those described in the discussion of the trim iteration page, Section 6.4.2.

6.8.2.3 Force and Moment Summary

This block of output is the same as described in Section 6.4.3. The forces and moments printed here are computed after the small increment in the pertinent variable has been made. All data are in the body reference system.

6.8.2.4 Delta Force and Moment Summary

This block of output presents the changes in the force and moment contributions in exactly the same format as the full force and moment summary. Each number in this block is obtained by taking the corresponding value from the force and moment summary immediately above, less the corresponding value at the trim condition or at the current maneuver time point.

6.8.3 Rotorcraft Stability Partial Derivative Matrices

6.8.3.1 Total Partial Derivative Matrix (Figure 64)

A summary of the partial derivatives computed from the data on the previous pages is printed on this page. Each row gives the partial derivatives of some force or moment, as labeled, with respect to the perturbation variables used.

STABILITY PARTIAL DERIVATIVES (TOTAL AIRCRAFT)

	U	W	Q	V	P	R
X-FORCE	-8.3394	7.5459	55.352	1.8953	48.130	-17.686
Z-FORCE	-5.9023	-296.73	-143.75	-6.7063	-1163.8	656.09
PITCH MOMENT	23.567	-80.652	-2338.7	-.63273	-268.04	58.646
Y-FORCE	.94801	-6.9593	-10.754	-54.426	-140.02	588.59
ROLL MOMENT	-2.3266	-55.312	.18066	-106.61	-765.69	2097.6
YAW MOMENT	-23.801	-42.227	1343.3	293.12	1237.9	-16357.
M.R. F/A FLAP MOM	-8.8450	21.355	32042.	384.24	.10460E+06	-686.42
M.R. LAT FLAP MOM	274.57	1121.6	-.10388E+06	113.73	34015.	1828.9
T.R. F/A FLAP MOM	-.69888	-1.8314	-46.589	-.36472	-535.86	-42.571
T.R. LAT FLAP MOM	-1.5471	-.11877	5.5432	5.8008	-21.760	340.07

	M.R. F/A FLAP RATE	M.R. LAT FLAP RATE	T.R. F/A FLAP RATE	T.R. LAT FLAP RATE	M.R. F/A FLAP DISP	M.R. LAT FLAP DISP	T.R. F/A FLAP DISP	T.R. LAT FLAP DISP
X-FORCE	40.796	39.561	.43457	-.14648E-01	-4727.2	-59.707	168.70	150.23
Z-FORCE	-12.656	-1116.6	-.54688	-.31250	14145.	-8355.9	255.23	-142.58
PITCH MOMENT	-287.48	-223.55	-14.840	-4.6851	32683.	839.60	5768.3	-3673.8
Y-FORCE	-2.0047	-52.856	.44830	-7.2519	348.72	2179.0	-21.134	-2714.3
ROLL MOMENT	-14.126	-373.31	1.2402	-30.791	2463.1	15391.	211.35	-11538.
YAW MOMENT	1109.1	-650.55	-12.656	193.28	31682.	13599.	365.23	72220.
M.R. F/A FLAP MOM	31968.	12.522	1.1310	1.1310	.22123E+06	.10993E+07	1.1310	1.1310
M.R. LAT FLAP MOM	9.9719	33197.	1.8579	1.8579	-.98256E+06	.24636E+06	1.8579	1.8579
T.R. F/A FLAP MOM	-.11043E-02	-.11043E-02	55.799	.26160	-.11043E-02	-.11043E-02	9960.3	10007.
T.R. LAT FLAP MOM	.96633E-02	.96633E-02	.26602	51.955	.96633E-02	.96633E-02	-8604.9	10121.

ROTOR PARTIAL DERIVATIVE MATRICES

MAIN ROTOR

	U	W	Q	V	P	R
THRUST	-4.1055	261.49	30.625	7.0242	1164.3	-656.09
H-FORCE	3.0559	-8.4713	-61.652	-.93149	-45.995	3.3557
F/A FLAPPING	.0	.0	.0	.0	.0	.0
Y-FORCE	-.58869	-6.8172	2.6736	-2.5296	-70.702	11.944
TORQUE	13.843	-51.034	1020.4	11.302	-570.31	-1369.4
LAT FLAPPING	.0	.0	.0	.0	.0	.0

TAIL ROTOR

	U	W	Q	V	P	R
THRUST	-.74902E-01	-.24746	-9.5703	10.426	47.163	-347.53
H-FORCE	.16027	.25443E-01	.62927	-.36575	-1.8701	12.443
F/A FLAPPING	.0	.0	.0	.0	.0	.0
Y-FORCE	.24032E-01	-.72484E-01	-2.0953	.93939E-01	.75733	-2.4786
TORQUE	.63716	.18765E-01	1.1554	.23138	6.6180	-14.463
LAT FLAPPING	.0	.0	.0	.0	.0	.0

Figure 64. Rotor and Total Partial Derivative Matrices.

6.8.3.2 Rotor Partial Derivative Matrix (Figure 64)

A summary of the rotor partial derivatives computed from the data on the previous pages is printed at the top of this page. Each row gives the partial derivatives of some force, moment, or flapping angle, as labeled, with respect to the linear and angular velocities U, W, Q, V, P, and R. The units are feet, pounds, radians, and seconds.

6.8.4 Mass, Damping, and Stiffness Matrices (Figure 65)

The mass, damping, and stiffness matrices which are used to calculate the rotorcraft stability characteristics are printed next. The reader is referred to Volume I of Reference 1 for the analytical background of these three matrices.

If IPL(89) = 1 or 2, these three matrices will be punched on cards. The punched output is headed by an identification card that consists of the IPSN input from CARD 01, the date, rotorcraft gross weight, cg stationline, groundspeed, and ambient temperature. Since the matrices are sparse, only the nonzero elements are punched. The format of the matrix element card is:

Column	
1	Matrix Indicator (I1)
6-8	Row Number of element (I2)
9-10	Column Number of element (I2)
11-25	Value of the element specified above (E15.8)
26-28	Row
29-30	Column
31-45	Value
46-48	Row
49-50	Column
51-65	Value
66-80	Date and Groundspeed

Values of the matrix indicator are

= 0 for stiffness matrix

= 1 for damping matrix

= 2 for mass matrix

The matrix indicator and each row and column number are integer inputs (I-format). The values of the elements are in scientific notation (E-format). Each matrix begins on a new card. An end-of-data card (I punched 20 times) follows the last card of the last matrix.

MASS MATRIX

	U DOT	W DOT	Q DOT	V DOT	P DOT	R DOT
X-FORCE	258.57	.0	.0	.0	.0	.0
Z-FORCE	.0	258.61	.0	.0	.0	.0
PITCH MOMENT	.0	.56197	11883.	.0	.0	.0
Y-FORCE	.0	.0	.0	258.57	.0	.0
ROLL MOMENT	.0	.0	.0	.0	2904.0	585.00
YAW MOMENT	.0	.0	.0	.0	585.00	10234.
M.R. F/A FLAP MOM	.0	.0	-1503.4	.0	.0	.0
M.R. LAT FLAP MOM	.0	.0	.0	.0	-1503.4	.0
T.R. F/A FLAP MOM	.0	.0	-.48102E-06	.0	.0	1.5320
T.R. LAT FLAP MOM	.0	.0	.0	.0	1.5320	.0

	M.R. F/A FLAP ACC.	M.R. LAT FLAP ACC.	T.R. F/A FLAP ACC.	T.R. LAT FLAP ACC.
X-FORCE	.0	.0	.0	.0
Z-FORCE	.0	.0	.0	.0
PITCH MOMENT	.0	.0	.0	.0
Y-FORCE	.0	.0	.0	.0
ROLL MOMENT	.0	.0	.0	.0
YAW MOMENT	.0	.0	.0	.0
M.R. F/A FLAP MOM	-1503.4	.0	.0	.0
M.R. LAT FLAP MOM	.0	-1503.4	.0	.0
T.R. F/A FLAP MOM	.0	.0	-1.5320	.0
T.R. LAT FLAP MOM	.0	.0	.0	-1.5320

DAMPING MATRIX

	U	W	Q	V	P	R
X-FORCE	8.3394	-7.5459	-3264.4	.0	.0	.0
Z-FORCE	5.9023	296.73	-56286.	.0	.0	.0
PITCH MOMENT	-23.567	80.652	2338.7	.0	.0	.0
Y-FORCE	.0	.0	.0	54.426	3349.1	55841.
ROLL MOMENT	.0	.0	.0	106.61	765.69	-2097.6
YAW MOMENT	.0	.0	.0	-293.12	-1237.9	16357.
M.R. F/A FLAP MOM	8.8450	-21.355	-32042.	-384.24	-.10460E+06	686.42
M.R. LAT FLAP MOM	-274.57	-1121.6	.10388E+06	-113.73	-34015.	-1828.9
T.R. F/A FLAP MOM	.69888	1.8314	46.589	.36472	535.86	42.571
T.R. LAT FLAP MOM	1.5471	.11877	-5.5432	-5.8008	21.760	-340.07

	M.R. F/A FLAP RATE	M.R. LAT FLAP RATE	T.R. F/A FLAP RATE	T.R. LAT FLAP RATE
X-FORCE	-40.796	-39.561	-.43457	.14648E-01
Z-FORCE	12.656	1116.6	.54688	.31250
PITCH MOMENT	287.48	223.55	14.840	4.6851
Y-FORCE	2.0047	52.856	-.44830	7.2519
ROLL MOMENT	14.126	373.31	-1.2402	30.791
YAW MOMENT	-1109.1	650.55	12.656	-193.28
M.R. F/A FLAP MOM	-31968.	-.10205E+06	.0	.0
M.R. LAT FLAP MOM	.10203E+06	-33197.	.0	.0
T.R. F/A FLAP MOM	.0	.0	-55.799	-531.80
T.R. LAT FLAP MOM	.0	.0	531.27	-51.955

Figure 65. Stability Matrices and Stick-Fixed Stability Results.

STIFFNESS MATRIX

	X	Z	THETA	Y	PHI	PSI
X-FORCE	.0	.0	8303.5	.0	.0	.0
Z-FORCE	.0	.0	-475.76	.0	.0	.0
PITCH MOMENT	.0	.0	.0	.0	.0	.0
Y-FORCE	.0	.0	.0	.0	-8303.5	475.76
ROLL MOMENT	.0	.0	.0	.0	.0	.0
YAW MOMENT	.0	.0	.0	.0	.0	.0
M.R. F/A FLAP MOM	.0	.0	.0	.0	.0	.0
M.R. LAT FLAP MOM	.0	.0	.0	.0	.0	.0
T.R. F/A FLAP MOM	.0	.0	.0	.0	.0	.0
T.R. LAT FLAP MOM	.0	.0	.0	.0	.0	.0

	M.R. F/A FLAP DISP	M.R. LAT FLAP DISP	T.R. F/A FLAP DISP	T.R. LAT FLAP DISP
X-FORCE	4727.2	59.707	-168.70	-150.23
Z-FORCE	-14145.	8355.9	-255.23	142.58
PITCH MOMENT	-32683.	-839.60	-5768.3	3673.8
Y-FORCE	-348.72	-2179.0	21.134	2714.3
ROLL MOMENT	-2463.1	-15391.	-211.35	11538.
YAW MOMENT	-31682.	-13599.	-365.23	-72220.
M.R. F/A FLAP MOM	-.22123E+06	-.10993E+07	.0	.0
M.R. LAT FLAP MOM	.98256E+06	-.24636E+06	.0	.0
T.R. F/A FLAP MOM	.0	.0	-9960.3	-10007.
T.R. LAT FLAP MOM	.0	.0	8604.9	-10121.

CONTROLS-FIXED ROOTS AND TRANSFER FUNCTION DENOMINATOR

	ROOTS REAL	ROOTS IMAG	DENOMINATORS TAU	DENOMINATORS DAMP	PERIOD	TIME TO HALF-DBL	CYCLES TO HALF-DBL	UNDAMPED NAT FREQ RAD/SEC	UNDAMPED NAT FREQ CPS	DAMPING RATIO
# 1	-.34852	.37778	3.7852	2.6384	16.632	1.989	0.120	.514	.818E-01	0.67805
# 2	.10936D-01	.26602	14.107	-.30854	23.619	63.383	2.684	.266	.424E-01	-0.04107
# 3	-.88739	.80276	.69838	1.2395	7.827	0.781	0.100	1.20	.190	0.74158
# 4	-1.1482	2.0657	.17904	.41113	3.042	0.604	0.198	2.36	.376	0.48583
# 5	-9.6961	.27492	.10628E-01	.20610	22.854	0.071	0.003	9.70	1.54	0.99960
# 6	-17.368	17.131	.16803E-02	.58368E-01	0.367	0.040	0.109	24.4	3.88	0.71194
# 7	-11.456	68.401	.20790E-03	.47634E-02	0.092	0.061	0.659	69.4	11.0	0.16518
# 8	-17.658	364.10	.75254E-05	.26577E-03	0.017	0.039	2.275	365.	58.0	0.04844

Figure 65. Concluded.

6.8.5 Stick-Fixed Rotorcraft Stability Results (Figure 65)

The rotorcraft characteristic equation, with controls fixed, is solved for its complex roots and associated response modes. These results are presented in several ways as discussed below.

6.8.5.1 Roots

The real and imaginary parts of the roots of the rotorcraft characteristic equation are printed under the headings REAL and IMAG. The units are radians per second. If z is the response of some mode, the response expression may be written directly in terms of the real and imaginary parts.

$$z = Ae^{(REAL*t)} \cos (IMAG*t) = A\ (REAL + IMAG*j)$$

where t = time

A = constant (dependent on initial condition)

In terms of the damping ratio, ζ, damped natural frequency, ω_d, and undamped natural frequency, ω_n, the printed roots are

$$REAL = \zeta\omega_n$$

$$IMAG = \omega_d = \omega_n\sqrt{1 - \zeta^2}$$

The roots may also be used to form the denominator, d(s), of the frequency response polynomial.

$$d(s) = \prod_{i=1}^{n} (s - REAL_i + IMAG_i*j)\ (s - REAL_i - IMAG_i*j)$$

where s = Laplace operator

$\prod$ = continued product notation

$j = \sqrt{-1}$

n = number of roots printed

i = sequence number of root in printout

Note that in the case of complex conjugate parts of roots, only the root with the positive imaginary part is printed.

6.8.5.2 Terms in Denominator of Laplace Transfer Function

Each root or pair of roots generates the terms in one factor of the denominator of the Laplace transfer function, D(s).

$$D(s) = \prod_{i=1}^{n} (TAU_i*s^2 + DAMP_i*s + 1)$$

where

$$TAU_i = 1/(REAL_i^2 + IMAG_i^2) = 1/\omega_{n_i}^2$$

$$DAMP_i = -2*REAL_i/(REAL_i^2 + IMAG_i^2) = -2\zeta_i/\omega_{n_i}$$

and $\prod$, n and i are as defined in the previous section.

6.8.5.3 Period

For the oscillatory roots of the rotorcraft characteristic equation, the period of the damped oscillation is given in seconds.

$$PERIOD = 2\pi/IMAG$$

For the roots with a zero imaginary part, the period is a meaningless concept, so a zero appears in the output.

6.8.5.4 Rate of Convergence or Divergence

The column headed TIME TO HALF-DBL depends only on the value of the real part of the root. If the real part is negative, the time to half amplitude, in seconds, is printed. If the real part is positive, the time to double amplitude in seconds is printed.

TIME TO HALF-DBL = ln(.5)/REAL

The column headed CYCLES TO HALF-DBL contains the number of cycles to half or double amplitude based on the damped natural frequency (IMAG) for the oscillatory roots.

CYCLES TO HALF-DBL = (TIME TO HALF-DBL)/PERIOD

A zero is printed for aperiodic roots.

6.8.5.5 Undamped Natural Frequency and Damping Ratio

The undamped natural frequency, ω_n, is based on the absolute value of the complex root.

$$\omega_n = \sqrt{REAL^2 + IMAG^2}$$

Thus, ω_n is defined even for an aperiodic root. The calculated value of ω_n is given both in radians per second and cycles per second. The damping ratio, ζ, in combination with the undamped natural frequency, completely describes the root.

$$\zeta = REAL/\omega_n$$

For a stable aperiodic root, the damping ratio is 1. For an unstable aperiodic root, the damping ratio is -1.

6.8.5.6 Stability Mode Shapes (Figure 66)

In the stability mode shape printout, each column represents one mode. The first column on the left is associated with the first root printed, the second with the second root, and so forth. Each component of a mode shape has a relative magnitude (MAGN) and a phase angle (PHASE). As implied by the column heading, magnitude is the top number of the pairs printed out and phase angle is the bottom. The normal printout provides for eight columns (mode shapes of roots). If more than eight roots are computed, the additional roots are printed in the same format below the first set. Columns after the last root are set to zero.

The mode shapes associated with the rotorcraft characteristic roots are first printed as normalized with respect to THETA, then as normalized with respect to PHI, and lastly as normalized with respect to the largest participation factor (variable). In all three sets of normalized mode shapes, the normalizing variable always has a magnitude of 1.000 (nondimensional) and a phase angle of 0.0 degrees. The fuselage degrees of freedom used for the mode shapes are not the same as those used in the rest of the rotorcraft stability analysis. The following variables are used.

U/VELOCITY = u/V = perturbation velocity in X-direction divided by total velocity (nondimensional)

C O N T R O L S - F I X E D   M O D E   S H A P E S

ROOT	# 1 MAGN PHASE	# 2 MAGN PHASE	# 3 MAGN PHASE	# 4 MAGN PHASE	# 5 MAGN PHASE	# 6 MAGN PHASE	# 7 MAGN PHASE	# 8 MAGN PHASE
----- NORMALIZED WRT THETA -----								
FUSELAGE								
U/VELOCITY	.7122E-01 -75.76	.5445 92.51	.1842 25.11	.1573 14.64	.3620 -1.014	.1023 -131.6	1.947 -83.93	2.514 116.9
ALPHA	10.49 141.8	.2307 72.29	1.349 62.91	1.379 158.3	.2691 -8.153	.9972 3.657	29.97 -24.58	2.871 80.01
THETA	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0
BETA	62.69 25.26	.4751E-01 -48.34	.3421 168.7	68.29 175.0	.5164 -115.6	9.979 -41.75	4.132 -2.612	66.46 -132.5
PHI	1044. 41.44	1.054 25.76	2.714 134.7	125.9 159.6	1.905 139.8	9.708 -50.29	4.212 -82.43	19.19 156.9
PSI	369.6 -106.4	.5278 -65.19	.7891 -17.78	79.69 -6.266	.5066 33.23	11.69 130.4	2.342 159.2	26.39 -23.04
M.R. F/A FLAP	7.248 158.9	.5901E-01 75.36	.3348 29.28	2.751 -103.1	32.88 -5.698	1.252 -73.72	1817. -112.6	.9946 -169.8
M.R. LAT FLAP	50.13 -11.17	.4138E-01 -84.27	.2639 88.36	30.74 76.06	29.28 139.4	11.61 155.1	1820. 158.1	19.18 -23.03
T.R. F/A FLAP	9.562 143.6	.6729E-02 56.06	.5262E-01 -117.3	7.819 -142.7	.8463 -51.78	946.6 -58.44	2.573 -169.2	.3367E+06 -151.8
T.R. LAT FLAP	20.56 -175.9	.2723E-01 102.8	.9045E-01 -57.47	13.46 -60.30	.4081 -12.19	941.3 36.19	5.088 -71.06	.3367E+06 118.2
----- NORMALIZED WRT PHI -----								
FUSELAGE								
U/VELOCITY	.6823E-04 -117.2	.5166 66.74	.6789E-01 -109.5	.1249E-02 -144.9	.1900 -140.8	.1175E-01 -81.31	.4623 -1.494	.1310 -39.94
ALPHA	.1004E-01 100.4	.2189 46.53	.4970 -71.75	.1095E-01 -1.265	.1413 -148.0	.1145 53.95	7.117 57.85	.1496 -76.85
THETA	.9580E-03 -41.44	.9489 -25.76	.3685 -134.7	.7941E-02 -159.6	.5249 -139.8	.1148 50.29	.2374 82.43	.5212E-01 -156.9
BETA	.6006E-01 -16.18	.4508E-01 -74.10	.1261 34.00	.5423 15.46	.2710 104.6	1.146 8.537	.9810 79.82	3.464 70.68
PHI	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0	1.000 .0
PSI	.3541 -147.8	.5008 -90.96	.2908 -152.4	.6328 -165.8	.2659 -106.6	1.342 -179.3	.5560 -118.4	1.375 -179.9
M.R. F/A FLAP	.6944E-02 117.4	.5600E-01 49.60	.1234 -105.4	.2185E-01 97.34	17.26 -145.5	.1438 -23.43	431.4 -30.21	.5184E-01 33.34
M.R. LAT FLAP	.4802E-01 -52.61	.3927E-01 -110.0	.9726E-01 -46.29	.2441 -83.51	15.37 -.4512	1.333 -154.6	432.1 -119.5	.9998 -179.9
T.R. F/A FLAP	.9160E-02 102.1	.6384E-02 30.29	.1939E-01 108.0	.6209E-01 57.69	.4442 168.4	108.7 -8.153	.6110 -86.79	.1755E+05 51.34
T.R. LAT FLAP	.1970E-01 142.7	.2584E-01 77.03	.3333E-01 167.9	.1069 140.1	.2142 -152.0	108.1 86.48	1.208 11.37	.1755E+05 -38.66

Figure 66. Examples of Mode Shapes of Stability Results.

----- NORMALIZED WRT LARGEST ---------------

FUSELAGE								
U/VELOCITY	.6823E-04 -117.2	.5166 66.74	.6789E-01 -109.5	.1249E-02 -144.9	.1101E-01 4.684	.1081E-03 -73.16	.1070E-02 118.0	.7467E-05 -1.279
ALPHA	.1004E-01 100.4	.2189 46.53	.4970 -71.75	.1095E-01 -1.265	.8185E-02 -2.455	.1053E-02 62.10	.1647E-01 177.3	.8525E-05 -38.19
THETA	.9580E-03 -41.44	.9489 -25.76	.3685 -134.7	.7941E-02 -159.6	.3042E-01 5.698	.1056E-02 58.44	.5494E-03 -158.1	.2970E-05 -118.2
BETA	.6006E-01 -16.18	.4508E-01 -74.10	.1261 34.00	.5423 15.46	.1571E-01 -109.9	.1054E-01 16.69	.2270E-02 -160.7	.1974E-03 109.3
PHI	1.000 .0	1.000 .0	1.000 .0	1.000 .0	.5795E-01 145.5	.9200E-02 8.153	.2314E-02 119.5	.5698E-04 38.66
PSI	.3541 -147.8	.5008 -90.96	.2908 -152.4	.6328 -165.8	.1541E-01 38.93	.1235E-01 -171.1	.1287E-02 1.069	.7836E-04 -141.2
M.R. F/A FLAP	.6944E-02 117.4	.5600E-01 49.60	.1234 -105.4	.2185E-01 97.34	1.000 .0	.1323E-02 -15.28	.9983 89.26	.2954E-05 72.00
M.R. LAT FLAP	.4802E-01 -52.61	.3927E-01 -110.0	.9726E-01 -46.29	.2441 -83.51	.8905 145.1	.1227E-01 -146.5	1.000 .0	.5696E-04 -141.2
T.R. F/A FLAP	.9160E-02 102.1	.6384E-02 30.29	.1939E-01 108.0	.6209E-01 57.69	.2574E-01 -46.08	1.000 .0	.1414E-02 32.68	.9998 90.00
T.R. LAT FLAP	.1970E-01 142.7	.2584E-01 77.03	.3333E-01 167.9	.1069 140.1	.1241E-01 -6.489	.9944 94.64	.2795E-02 130.8	1.000 .0

Figure 66. Concluded.

ALPHA = w/V = perturbation velocity in Z-direction divided by total velocity (nondimensional); approximately the same as angle of attack (radians)

THETA = $\int q\,dt$ = the integral of the pitch rate (radians); approximately the same as pitch angle

BETA = $\Delta v/V$ = perturbation velocity in Y-direction divided by total velocity (radians); approximately the same as sideslip angle

PHI = $\int p\,dt$ = integral of roll rate (radians); approximately the same as roll angle

PSI = $\int r\,dt$ = integral of yaw rate (radians); approximately the same as yaw angle

If activated, the pylon and flapping variables are all given as angular displacements in radians.

6.8.6 Transfer Function Numerator (Figure 67)

Following the mode shapes, the numerators of the transfer functions for aircraft response and/or flapping angles as specified by IPL(93) are printed. For each of the numerators printed, the value labeled GAIN is the constant term in the frequency response polynomial; STATIC GAIN is the gain term to be used in the Laplace transfer function.

The complex roots of the frequency response polynomial are printed in pairs of columns labeled REAL and IMAG. Below the real and imaginary roots are the corresponding values in the numerator of the Laplace transfer function, TAU and DAMP. The numerator of the Laplace transfer function, N(s), may be written as follows:

$$N(s) = (\text{STATIC GAIN}) * \prod_{k=1}^{M} (\text{TAU}_k * s^2 + \text{DAMP}_k * s + 1)$$

The STATIC GAIN is the ratio N(s)/D(s) evaluated for s = 0.

The frequency response polynomial is

$$n(s) = (\text{GAIN}) * \prod_{k=1}^{M} [\,(s-\text{REAL}_k + \text{IMAG}_k * j)$$

$$(s-\text{REAL}_k - \text{IMAG}_k * j)\,]$$

TRANSFER FUNCTION DATA

THETA / LONG CYC		PHI / LAT CYC		PSI / PEDAL	
NUMERATORS					
GAIN =	.81003E-01	GAIN =	-.30594	GAIN =	1.4051
REAL	IMAG	REAL	IMAG	REAL	IMAG
-.34930	.37822	-.80827E-02	.0	.87665E-02	.26312
-.24734E-01	.0	.61130E-02	.25909	.24955	.67966
-1.2275	.0	-.83665	.83089	-.86816	.79566
-1.1385	2.0634	-.85934	2.1074	-1.4659	.0
-10.056	.0	-9.3657	.0	-9.6502	.18123
-17.379	17.133	-16.720	.0	-17.546	14.688
-34.650	.0	-17.471	17.047	-11.460	68.401
-3.8917	63.499	-7.5434	65.226	-15.219	361.84
-17.658	364.10	-17.657	364.10	.0	.0
STATIC GAIN =	.75377E-01	STATIC GAIN =	-.11928E-01	STATIC GAIN =	.59577
TAU	DAMP	TAU	DAMP	TAU	DAMP
3.7727	2.6356	.0	123.72	14.428	-.25297
.0	40.430	14.889	-.18204	1.9076	-.95208
.0	.81469	.71924	1.2035	.72110	1.2521
.18005	.40999	.19306	.33181	.0	.68216
.0	.99445E-01	.0	.10677	.10734E-01	.20718
.16791E-02	.58362E-01	.0	.59810E-01	.19099E-02	.67021E-01
.0	.28860E-01	.16783E-02	.58643E-01	.20790E-03	.47650E-02
.24708E-03	.19232E-02	.23195E-03	.34993E-02	.76245E-05	.23207E-03
.75254E-05	.26577E-03	.75254E-05	.26575E-03	.0	.0

Figure 67. Numerator of Transfer Functions.

where k = sequence number of root

M = total number of roots printed

The complete transfer function, $G(s)$, can then be formed as either

$$G(s) = N(s)/D(s)$$

or

$$G(s) = n(s)/d(s)$$

where $D(s)$ and $d(s)$ are the denominator of the transfer function and the frequency response polynominal discussed in section 6.8.5.2.

Zero roots are not printed for either the stick fixed or control input solutions, so the final order of the transfer function generated as described above may be incorrect. In this case usually one more "s" in the denominator will correct the situation. The need for this correction may be found by inspecting the numerator and denominator polynomials. The transfer function is correct when the highest power of "s" for the denominator is 2 larger than that for the numerator.

6.8.7 Frequency Response (Figure 68)

The frequency response of the transfer functions is tabulated following the transfer function numerator printout. The data listed are the frequency in hertz and radians per second, the gain in the decibel equivalent of a magnitude in degrees per inch of control, and the phase in degrees. The range of frequencies is 0.01 to 100 radians per second. Construction of a Bode plot for each transfer function is greatly simplified with these data.

6.9 BLADE ELEMENT AERODYNAMIC AND DIAGNOSTIC DATA

The user can print blade element aerodynamic data and diagnostic information for either rotor for trim or maneuver by selecting the proper values of IPL(75) and IPL(76). If these inputs are less than 2, no additional data are printed. If the value equals 2, blade element aerodynamic data are printed during maneuver at the times specified in the Blade Element Data Printout Group.

The aerodynamic data are composed of blocks of data where each block presents data at all blade radial stations for one blade of one rotor at a single blade azimuth location. The printout

FREQUENCY RESPONSE

FREQ(RAD/SEC)	GAIN(DB)	PHASE(DEG)	GAIN(DB)	PHASE(DEG)	GAIN(DB)	PHASE(DEG)	FREQ(HZ)
0.0100	13.377	21.899	40.725	-40.476	70.663	-91.858	0.0016
0.0125	13.715	26.668	40.059	-34.798	68.724	-92.322	0.0020
0.0160	14.257	32.715	39.528	-29.248	66.579	-92.973	0.0025
0.0200	14.942	38.731	39.197	-25.063	64.639	-93.717	0.0032
0.0250	15.842	45.022	38.971	-21.740	62.699	-94.648	0.0040
0.0300	16.749	50.156	38.842	-19.668	61.112	-95.579	0.0048
0.0350	17.636	54.359	38.761	-18.359	59.770	-96.513	0.0056
0.0400	18.490	57.824	38.707	-17.546	58.606	-97.447	0.0064
0.0500	20.088	63.133	38.640	-16.840	56.659	-99.321	0.0080
0.0600	21.545	66.958	38.599	-16.869	55.063	-101.20	0.0095
0.0700	22.885	69.817	38.569	-17.326	53.710	-103.10	0.0111
0.0800	24.133	72.026	38.545	-18.056	52.533	-105.00	0.0127
0.1000	26.437	75.221	38.498	-20.013	50.551	-108.84	0.0159
0.1250	29.133	77.943	38.428	-22.993	48.538	-113.73	0.0199
0.1600	32.948	80.861	38.263	-27.637	46.234	-120.75	0.0255
0.2000	38.142	84.979	37.819	-33.032	43.967	-128.99	0.0318
0.2500	49.971	109.78	33.794	-45.002	40.356	-141.55	0.0398
0.3000	45.491	-123.05	39.843	-64.164	40.637	-159.09	0.0477
0.3500	38.633	-113.68	38.863	-68.176	38.409	-169.66	0.0557
0.4000	35.148	-112.25	38.152	-76.620	36.334	176.80	0.0637
0.5000	31.133	-113.54	36.535	-94.223	32.203	146.75	0.0796
0.6000	28.621	-116.67	34.580	-109.48	28.364	113.73	0.0955
0.7000	26.744	-120.65	32.487	-121.55	25.616	79.488	0.1114
0.8000	25.186	-125.13	30.419	-130.84	24.336	49.071	0.1273
1.0000	22.504	-134.65	26.620	-143.62	24.029	8.9219	0.1592
1.2500	19.471	-145.86	22.561	-153.31	24.304	-18.447	0.1989
1.6000	15.568	-158.16	17.816	-160.60	24.458	-43.747	0.2546
2.0000	11.660	-167.68	13.449	-162.42	24.041	-68.655	0.3183
2.5000	7.5798	-175.47	9.8079	-160.46	22.297	-96.301	0.3979
3.0000	4.1902	179.06	7.3638	-161.59	19.654	-116.62	0.4775
3.5000	1.2924	174.83	5.1874	-164.87	16.887	-129.94	0.5570
4.0000	-1.2435	171.37	3.1277	-168.32	14.337	-138.65	0.6366
5.0000	-5.5466	165.84	-.59798	-173.98	10.046	-148.83	0.7958
6.0000	-9.1413	161.49	-3.8227	-178.11	6.6134	-154.37	0.9549
7.0000	-12.250	157.95	-6.6394	178.81	3.7790	-157.76	1.1141
8.0000	-15.001	155.02	-9.1327	176.46	1.3726	-160.01	1.2732
10.0000	-19.727	150.58	-13.386	173.27	-2.5536	-162.75	1.5915
12.5000	-24.605	146.95	-17.712	171.03	-6.3660	-164.64	1.9894
16.0000	-30.137	144.22	-22.528	169.63	-10.458	-166.35	2.5465
20.0000	-35.207	143.02	-26.868	169.16	-14.084	-168.14	3.1831
25.0000	-40.294	142.92	-31.181	169.20	-17.734	-170.48	3.9789
30.0000	-44.454	143.41	-34.697	169.41	-20.801	-172.57	4.7746
35.0000	-48.002	143.95	-37.691	169.62	-23.459	-174.20	5.5704
40.0000	-51.169	144.27	-40.341	169.77	-25.795	-175.38	6.3662
50.0000	-57.237	144.17	-45.148	170.46	-29.731	-176.86	7.9577
60.0000	-65.687	156.91	-50.064	178.24	-32.950	-177.70	9.5493
70.0000	-63.607	-144.12	-51.234	-158.40	-35.668	-178.23	11.1408
80.0000	-62.075	-162.17	-51.174	-164.79	-38.019	-178.59	12.7324
100.0000	-65.720	-177.12	-54.725	-174.13	-41.936	-179.03	15.9155

Figure 68. Frequency Response of Transfer Functions.

of the set of data blocks precedes the maneuver-time-point page with which it is associated. When data for both rotors are to be printed, the data for Rotor 1 precedes that for Rotor 2.

The number of data blocks included in the printout for one rotor depends on which rotor analysis (time-variant or quasi-static) is active for the rotor in question at the time of printout. When the time-variant rotor analysis is active, the number of blocks also depends on the number of blades on the rotor. The format of each block depends on which, if either, of the unsteady aerodynamic options is active.

If the quasi-static rotor analysis is active for a rotor when aerodynamic data are to be printed, the set of data printed for that rotor consists of a data block for each of 12 azimuth locations (30-degree increments) of a representative blade. If the time-variant rotor analysis is active, the set of data for the rotor consists of one data block for each blade at the azimuth angle corresponding to the maneuver time point, i.e., two to seven data blocks.

The data blocks consist of six parameters that are independent of blade radial station and nine or fourteen parameters that can vary with radial station. The printout includes nine parameters when the unsteady aerodynamic options are turned off; when either unsteady option is active, five additional parameters are included. Of these five additional parameters, three are the same regardless of which option is active, while the remaining two are a function of the active option. All parameters are defined in Table 27.

If IPL(75) or IPL(76) equals 3, then the aerodynamic data are printed for the trim case as well as the subsequent maneuver. The trim output is of the same format as the maneuver aerodynamic output. Diagnostic information is also printed whenever IPL(75) or IPL(76) is greater than 3. The local programmer should be consulted for an interpretation of these additional output data.

Figure 69 contains examples of blade element aerodynamic data printed during a maneuver. The data are for a two-bladed time-variant rotor with the unsteady aerodynamic option off, the BUNS option on, and the UNSAN option on.

6.10 BLADE ELEMENT BENDING MOMENT DATA

When the time-variant rotor analysis is active, a tabulation of the instantaneous values of beam, chord, and torsional moments at each radial station on each blade is printed at the times

TABLE 27. DEFINITIONS OF BLADE ELEMENT AERODYNAMIC PARAMETERS

Parameters That are Independent of Radial Station
(All six parameters included in each printout)

Name	Description	Units
PSI	Azimuth location of blade	deg
U-HUB	Shaft reference X-component of velocity at rotor hub	ft/sec
V-HUB	Shaft reference Y-component of velocity at rotor hub	ft/sec
W-HUB	Shaft reference Z-component of velocity at rotor hub	ft/sec
GEO PITCH	Geometric blade pitch angle at Station 0 (root) for azimuth location PSI	deg
BETA (HUB)	Flapping angle at the hub (i.e., the angle between the shaft reference X-Y plane and the blade pitch-change axis at Station 0) for azimuth location PSI	deg

Parameters Which are Dependent on Radial Station

Name	Printout Code *	Description	Units
STA	A	Blade station number starting at the tip and continuing to Station 1	-
UT	A	Tangential component of the total local velocity, i.e., component that is perpendicular to the local pitch-change axis and parallel to the local chord line	ft/sec
UP	A	Perpendicular component of the total velocity, i.e., component that is perpendicular to both the local pitch-change axis and the local chordline	ft/sec
UR	A	Radial component of the total local velocity, i.e., component that is parallel to the local pitch-change axis	ft/sec
MACH	A	Local Mach number	-
ALPHA	A	Local angle of attack	deg

TABLE 27. (Concluded)

Name	Printout Code *	Description	Units
CL	A	Total local lift coefficient including unsteady aerodynamic effects if any	-
DCL	B	Increment to local steady state lift coefficient from the BUNS option; included in the value of CL	-
CDR	U	Radial component of drag coefficient from the UNSAN option	-
CM	A	Total local pitching moment coefficient including unsteady aerodynamic effects if any	-
DCM	B	Increment to local steady state pitching moment coefficient from the BUNS unsteady aerodynamic option; included in the value of CM	-
HVDD	U	Second time derivative of the oscillatory part of the local blade position (h_v); equivalent to the first time derivative of the oscillatory part of the local heaving velocity	ft/sec^2
ALPHAD	B&U	Alpha dot, the first time derivative of ALPHA	deg/sec
THETAD	B&U	Theta dot, the first time derivative of theta (the local blade pitch angle)	deg/sec
THETADD	B&U	Theta double dot, the second time derivative of theta (derivative of THETAD)	deg/sec^2

*Printout code definition:

A = variable always included in printout

B = variable included in printout only when BUNS unsteady aerodynamic option is active

U = variable included in printout only when UNSAN unsteady aerodynamic option is active

B&U = variable included in the printout only when one of the unsteady aerodynamic options is active

PSI = 127.   U-HUB = 224.16   V-HUB = -1.57   W-HUB = -22.67   GEO. PITCH = 12.06   BETA(HUB) = 3.82

STA	UT	UP	UR	MACH	ALPHA	CL	CD	CM
20	924.69	-15.91	135.40	0.847	-0.864	-0.1149	0.05817	0.03485
19	887.41	-15.94	135.41	0.813	-0.415	-0.0626	0.02811	0.01513
18	851.53	-15.80	135.45	0.781	0.027	0.0042	0.01515	-0.00063
17	812.81	-15.48	135.52	0.746	0.527	0.0830	0.01199	-0.00276
16	778.60	-14.95	135.62	0.715	0.986	0.1512	0.01274	-0.00267
15	738.17	-14.29	135.74	0.678	1.531	0.2252	0.01197	-0.00222
14	700.84	-13.62	135.85	0.644	2.043	0.2874	0.01135	-0.00274
13	663.51	-12.93	135.95	0.611	2.563	0.3473	0.01131	-0.00325
12	618.86	-12.37	136.03	0.571	3.171	0.4134	0.01156	-0.00406
11	588.90	-11.93	136.09	0.544	3.592	0.4570	0.01216	-0.00449
10	551.61	-11.58	136.15	0.510	4.098	0.5052	0.01235	-0.00493
9	514.32	-11.34	136.19	0.477	4.586	0.5558	0.01225	-0.00545
8	469.71	-11.31	136.22	0.437	5.115	0.6121	0.01240	-0.00600
7	438.77	-11.34	136.24	0.410	5.445	0.6469	0.01265	-0.00634
6	408.97	-11.41	136.27	0.383	5.752	0.6789	0.01291	0.0
5	365.18	-11.77	136.29	0.344	6.087	0.7140	0.01290	0.0
4	327.87	-12.28	136.29	0.311	6.257	0.7326	0.01286	0.0
3	284.62	-13.00	136.29	0.273	0.0	0.0	0.13000	0.0
2	236.81	-13.70	136.31	0.232	0.0	0.0	0.13000	0.0
1	195.65	-13.34	136.43	0.197	0.0	0.0	0.13000	0.0

PSI = 307.   U-HUB = 224.16   V-HUB = -1.57   W-HUB = -22.67   GEO. PITCH = 20.02   BETA(HUB) = 1.55

STA	UT	UP	UR	MACH	ALPHA	CL	CD	CM
20	566.83	-39.21	-134.24	0.525	4.638	0.5759	0.01398	-0.00537
19	529.58	-38.58	-134.26	0.491	4.909	0.5972	0.01259	-0.00586
18	493.74	-37.97	-134.29	0.459	5.146	0.6195	0.01257	-0.00607
17	456.07	-37.35	-134.32	0.425	5.360	0.6387	0.01259	-0.00626
16	420.91	-36.82	-134.34	0.394	5.503	0.6505	0.01262	-0.00637
15	380.54	-36.21	-134.37	0.358	5.593	0.6564	0.01245	-0.00643
14	343.27	-35.65	-134.40	0.326	5.578	0.6522	0.01214	-0.00639
13	306.00	-35.10	-134.43	0.293	5.432	0.6378	0.01180	-0.00625
12	261.37	-34.45	-134.47	0.254	5.014	0.6061	0.01160	-0.00594
11	231.43	-34.00	-134.50	0.229	4.534	0.5637	0.01137	-0.00553
10	194.35	-33.41	-134.53	0.197	3.614	0.4727	0.01099	-0.00464
9	156.86	-32.78	-134.56	0.166	2.212	0.3133	0.01061	-0.00308
8	112.23	-32.00	-134.60	0.130	-0.344	-0.0577	0.00981	0.00057
7	82.29	-31.42	-134.63	0.106	-2.651	-0.5465	0.01129	0.00537
6	51.50	-30.76	-134.66	0.095	-7.292	-1.5686	0.16114	0.01306
5	7.73	-29.78	-134.70	0.089	-29.273	-1.9525	1.62576	0.32328
4	-29.54	-28.91	-134.73	0.091	-118.177	0.7051	1.69146	0.50000
3	-72.74	-27.92	-134.74	0.100	0.0	0.0	0.13000	0.0
2	-120.56	-26.91	-134.73	0.136	0.0	0.0	0.13000	0.0
1	-161.76	-26.91	-134.54	0.169	0.0	0.0	0.13000	0.0

a) Printout with the unsteady aerodynamic options off.

Figure 69. Blade Element Aerodynamic Data.

PSI = 127. U-HUB = 224.16 V-HUB = -1.70 W-HUB = -22.42 GEO. PITCH = 11.54 BETA(HUB) = 3.85

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	924.75	-12.61	135.35	0.847	-0.900	-0.10358	0.01617	0.05890	0.04005	0.00387	75.11	61.57	35882.64
19	887.46	-12.87	135.36	0.813	-0.458	-0.05162	0.01742	0.02834	0.02054	0.00403	78.27	61.77	35869.06
18	851.58	-12.97	135.39	0.781	-0.026	0.01485	0.01889	0.01515	0.00463	0.00422	82.26	62.32	35913.33
17	812.86	-12.95	135.45	0.746	0.458	0.09288	0.02074	0.01165	-0.00707	-0.00446	87.44	63.29	35879.31
16	778.65	-12.72	135.53	0.715	0.898	0.16029	0.02265	0.01237	-0.00735	-0.00471	92.90	64.40	35847.55
15	738.22	-12.43	135.63	0.678	1.415	0.23326	0.02515	0.01160	-0.00734	-0.00505	99.34	65.96	35805.62
14	700.89	-12.12	135.72	0.644	1.896	0.29448	0.02772	0.01107	-0.00832	-0.00542	105.21	67.65	35747.60
13	663.55	-11.78	135.82	0.611	2.382	0.35319	0.03054	0.01105	-0.00921	-0.00585	110.88	69.53	35649.54
12	618.89	-11.60	135.89	0.571	2.945	0.41811	0.03419	0.01132	-0.01040	-0.00629	116.12	71.95	35515.88
11	588.92	-11.40	135.95	0.544	3.333	0.46095	0.03694	0.01166	-0.01114	-0.00661	119.69	73.71	35380.20
10	551.62	-11.32	136.00	0.510	3.799	0.50912	0.04057	0.01204	-0.01264	-0.00765	122.86	75.80	35213.46
9	514.32	-11.29	136.04	0.477	4.249	0.55960	0.04454	0.01200	-0.01448	-0.00898	125.09	77.74	35042.80
8	469.69	-11.47	136.07	0.437	4.739	0.61690	0.04972	0.01213	-0.01651	-0.01046	125.78	79.64	34842.07
7	439.75	-11.58	136.10	0.410	5.048	0.65341	0.05368	0.01218	-0.01819	-0.01179	125.71	80.77	34711.17
6	408.95	-11.69	136.13	0.383	5.341	0.68487	0.05451	0.01230	-0.01214	-0.01214	125.13	81.77	34587.59
5	365.17	-12.03	136.16	0.344	5.667	0.72597	0.06147	0.01242	-0.01437	-0.01437	122.32	83.01	34431.65
4	327.88	-12.47	136.17	0.311	5.840	0.75210	0.06853	0.01224	-0.01669	-0.01669	117.80	83.92	34315.21
3	284.66	-13.10	136.17	0.273	0.0	0.0	0.06853	0.13000	0.0	-0.01669	0.0	83.92	34315.21
2	236.87	-13.64	136.19	0.232	0.0	0.0	0.06853	0.13000	0.0	-0.01669	0.0	83.92	34315.21
1	195.73	-13.05	136.32	0.197	0.0	0.0	0.06853	0.13000	0.0	-0.01669	0.0	83.92	34315.21

PSI = 307. U-HUB = 224.16 V-HUB = -1.70 W-HUB = -22.42 GEO. PITCH = 20.54 BETA(HUB) = 1.52

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	566.82	-40.80	-134.22	0.525	5.545	0.62121	-0.06299	0.01721	-0.01293	-0.00747	-187.37	-156.26	-33456.88
19	529.52	-40.38	-134.24	0.491	5.778	0.63521	-0.06740	0.01401	-0.01110	-0.00487	-184.51	-158.18	-33461.29
18	493.63	-39.96	-134.26	0.459	5.974	0.64675	-0.07213	0.01411	-0.00835	-0.00202	-180.86	-157.84	-33472.75
17	454.91	-39.48	-134.29	0.425	6.139	0.65367	-0.07785	0.01402	-0.00461	0.00179	-175.77	-157.04	-33467.50
16	420.71	-39.02	-134.31	0.394	6.238	0.65397	-0.08365	0.01407	-0.00210	0.00430	-170.28	-156.09	-33467.17
15	380.31	-38.42	-134.34	0.358	6.278	0.64542	-0.09161	0.01394	0.00104	0.00735	-161.94	-154.72	-33475.27
14	343.02	-37.79	-134.37	0.326	6.218	0.62712	-0.10021	0.01311	0.00428	0.01042	-151.54	-153.13	-33469.29
13	305.74	-37.09	-134.41	0.293	6.033	0.59812	-0.11032	0.01229	0.01158	0.01744	-137.31	-151.22	-33477.34
12	261.12	-36.19	-134.44	0.254	5.571	0.54909	-0.12452	0.01204	0.01866	0.02404	-111.37	-148.55	-33465.04
11	231.19	-35.52	-134.47	0.226	5.064	0.49459	-0.13519	0.01175	0.02238	0.02723	-85.17	-146.41	-33458.41
10	193.92	-34.65	-134.50	0.197	4.112	0.38963	-0.14833	0.01125	0.02671	0.03054	-34.07	-143.63	-33453.09
9	156.66	-33.72	-134.53	0.166	2.673	0.22433	-0.15450	0.01090	0.03298	0.03519	57.09	-140.75	-33429.72
8	112.06	-32.59	-134.57	0.130	0.059	-0.09302	-0.10292	0.00980	0.04557	0.04466	302.24	-137.52	-33398.39
7	82.13	-31.79	-134.60	0.106	-2.306	-0.35491	0.12095	0.01099	-0.05300	-0.05649	711.35	-135.30	-33381.40
6	51.37	-30.93	-134.63	0.096	-6.943	-0.29246	1.20133	0.14625	-0.06217	-0.03683	1819.61	-133.12	-33349.85
5	7.61	-29.71	-134.66	0.089	-28.927	1.63226	3.75180	1.24779	0.47500	0.15562	2804.79	-130.23	-33314.90
4	-29.66	-28.70	-134.68	0.091	-117.633	3.78987	3.09963	1.70234	0.65564	0.15564	2804.79	-127.93	-33294.96
3	-72.86	-27.58	-134.70	0.100	0.0	0.0	3.09963	0.13000	0.0	0.15564	0.0	-127.93	-33294.96
2	-120.67	-26.47	-134.68	0.136	0.0	0.0	3.09963	0.13000	0.0	0.15564	0.0	-127.93	-33294.96
1	-161.85	-26.54	-134.47	0.169	0.0	0.0	3.09963	0.13000	0.0	0.15564	0.0	-127.93	-33294.96

b) Printout with the BUNS unsteady aerodynamic option active.

Figure 69. Continued.

PSI = 127. U-HUB = 224.16 V-HUB = -2.59 W-HUB = -23.25 GEO. PITCH = 12.50 BETA(HUB) = 3.87

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	924.00	-21.13	134.50	0.851	-0.790	-0.07077	0.03168	0.05920	0.02643	-0.00515	150.54	137.24	61108.91
19	886.83	-20.73	134.51	0.817	-0.322	-0.01023	0.03708	0.03024	0.00502	-0.00637	152.11	137.64	61114.10
18	851.08	-20.23	134.54	0.785	0.137	0.05843	0.06922	0.01620	-0.01100	-0.00709	154.63	138.70	61115.34
17	812.43	-19.59	134.60	0.750	0.653	0.13005	0.11390	0.01312	-0.01168	-0.00766	158.45	140.47	61106.98
16	778.31	-18.84	134.68	0.720	1.123	0.19447	0.15707	0.01372	-0.01247	-0.00854	162.93	142.55	61090.75
15	737.97	-17.98	134.77	0.684	1.679	0.26798	0.21221	0.01290	-0.01232	-0.00968	168.76	145.55	61068.89
14	700.73	-17.19	134.86	0.650	2.199	0.33350	0.26699	0.01172	-0.01389	-0.01086	174.62	148.86	61036.88
13	663.48	-16.41	134.95	0.617	2.725	0.39645	0.32402	0.01174	-0.01574	-0.01215	180.85	152.59	61004.88
12	618.92	-15.75	135.02	0.577	3.342	0.46081	0.38969	0.01131	-0.01795	-0.01343	187.64	157.44	60940.71
11	589.02	-15.26	135.07	0.551	3.769	0.50322	0.43636	0.01136	-0.01945	-0.01450	192.76	161.04	60887.70
10	551.79	-14.82	135.12	0.518	4.288	0.55164	0.49626	0.01136	-0.02122	-0.01581	198.29	165.41	60821.56
9	514.58	-14.46	135.15	0.485	4.796	0.60088	0.56307	0.01129	-0.02328	-0.01739	203.24	169.61	60752.04
8	470.05	-14.24	135.18	0.446	5.364	0.66145	0.65533	0.01112	-0.02614	-0.01966	207.51	173.95	60680.69
7	440.16	-14.10	135.20	0.420	5.734	0.70002	0.72197	0.01097	-0.02836	-0.02151	210.14	176.74	60635.06
6	409.43	-13.96	135.22	0.393	6.097	0.72902	0.76459	0.01085	-0.02206	-0.02206	212.30	179.38	60599.48
5	366.73	-13.95	135.24	0.356	6.545	0.76691	0.86502	0.01055	-0.02520	-0.02520	213.61	182.80	60562.45
4	328.52	-14.09	135.25	0.324	6.848	0.79367	0.96075	0.01032	-0.02861	-0.02861	212.92	185.48	60541.83
3	286.38	-14.36	135.25	0.288	0.0	0.0	0.96075	0.13000	0.0	-0.02861	0.0	185.48	60541.83
2	237.67	-14.54	135.26	0.249	0.0	0.0	0.96075	0.13000	0.0	-0.02861	0.0	185.48	60541.83
1	196.60	-13.97	135.35	0.218	0.0	0.0	0.96075	0.13000	0.0	-0.02861	0.0	185.48	60541.83

PSI = 307. U-HUB = 224.16 V-HUB = -2.59 W-HUB = -23.25 GEO. PITCH = 19.57 BETA(HUB) = 1.52

STA	UT	UP	UR	MACH	ALPHA	CL	DCL	CD	CM	DCM	ALPHAD	THETAD	THETADD
20	566.37	-36.74	-133.14	0.531	6.231	0.68098	-0.20548	0.03097	0.01856	0.02404	-372.52	-338.55	-60111.06
19	528.96	-37.07	-133.16	0.498	6.437	0.68146	-0.24228	0.02888	0.02015	0.02523	-367.59	-338.57	-60099.60
18	492.97	-37.38	-133.17	0.466	6.599	0.67366	-0.27653	0.03465	0.02215	0.02640	-362.04	-338.39	-60110.25
17	454.15	-37.67	-133.19	0.432	6.726	0.67451	-0.32034	0.03783	0.02314	0.02858	-354.74	-337.65	-60148.00
16	419.87	-37.84	-133.21	0.403	6.789	0.68175	-0.36698	0.03910	0.02489	0.03150	-347.55	-336.77	-60179.89
15	379.38	-37.91	-133.23	0.368	6.790	0.68312	-0.42540	0.03717	0.02922	0.03572	-337.10	-335.57	-60242.76
14	342.02	-37.82	-133.26	0.336	6.701	0.67597	-0.48658	0.03183	0.03449	0.04083	-324.71	-334.13	-60313.34
13	304.67	-37.58	-133.29	0.305	6.495	0.65460	-0.55598	0.02428	0.04124	0.04761	-308.31	-332.33	-60397.41
12	260.00	-37.12	-133.32	0.268	6.018	0.58337	-0.63173	0.02284	0.05158	0.05730	-278.40	-329.66	-60528.77
11	230.04	-36.67	-133.35	0.245	5.495	0.52134	-0.69808	0.02079	0.06322	0.06834	-249.18	-327.43	-60618.13
10	192.75	-36.01	-133.39	0.216	4.478	0.37635	-0.80776	0.01622	0.08156	0.08526	-192.38	-324.38	-60754.96
9	156.47	-35.23	-133.43	0.189	2.798	0.13574	-0.70311	0.01192	0.11030	0.11164	-92.36	-321.08	-60877.10
8	110.87	-34.19	-133.47	0.161	-0.975	-0.21710	0.70281	0.06371	0.07374	0.07159	174.14	-317.20	-61011.96
7	80.95	-33.40	-133.51	0.145	-5.859	-0.41753	0.43000	0.39349	0.16084	0.04723	611.89	-314.44	-61100.82
6	50.20	-32.51	-133.55	0.133	-15.959	-0.83736	0.22053	0.72765	0.21600	0.03122	1763.25	-311.66	-61168.51
5	6.48	-31.21	-133.59	0.125	-60.725	-0.48167	-0.08956	1.93996	-0.02268	-0.45550	2864.79	-307.90	-61257.70
4	-30.75	-30.08	-133.62	0.128	-117.587	0.82424	0.13525	1.70327	0.26114	-0.23886	2864.79	-304.86	-61298.59
3	-73.90	-28.79	-133.64	0.142	0.0	0.0	0.13525	0.13000	0.0	-0.23886	0.0	-304.86	-61298.59
2	-121.66	-27.48	-133.63	0.167	0.0	0.0	0.13525	0.13000	0.0	-0.23886	0.0	-304.86	-61298.59
1	-162.78	-27.37	-133.41	0.193	0.0	0.0	0.13525	0.13000	0.0	-0.23886	0.0	-304.86	-61298.59

c) Printout with the UNSAN unsteady aerodynamic option active.

Figure 69. Concluded.

specified in the Blade Element Printout Times Group. The values of IPL(75) and IPL(76) specify the rotor(s) to be included in the printout. Data are printed at all radial stations, with Station IPL(4) -1 (IPL(5) -1 for Rotor 2) printed first and Station 0 (the root) last. The tip station is omitted from the printout since all moments are defined to be zero at this point. The units for all three moments are inch-pounds.

Figure 70 contains an example of the printout for one rotor. The printout of these data follows the rotor elastic response (Figure 60) of the time point with which they are associated. If data for both rotors are to be printed, the data for Rotor 1 are printed first.

It is emphasized that these bending moment data are only printed for a rotor that uses the time-variant solution procedure; if IPL(75) or IPL(76) specify that data be printed for a rotor which uses the quasi-static solution procedure, the program ignores the input and does not print any moment data.

MAIN ROTOR

BEAM BENDING MOMENT

STATION	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
0	-26951.512	-26951.512	0.0	0.0	0.0	0.0	0.0
1	-13784.871	-12860.109	0.0	0.0	0.0	0.0	0.0
2	-16389.930	-2301.788	0.0	0.0	0.0	0.0	0.0
3	-14067.184	5249.191	0.0	0.0	0.0	0.0	0.0
4	-10305.867	7193.273	0.0	0.0	0.0	0.0	0.0
5	-7084.324	6575.855	0.0	0.0	0.0	0.0	0.0
6	-5271.328	6022.133	0.0	0.0	0.0	0.0	0.0
7	-4972.922	5718.332	0.0	0.0	0.0	0.0	0.0
8	-5332.371	5338.480	0.0	0.0	0.0	0.0	0.0
9	-6423.961	4735.453	0.0	0.0	0.0	0.0	0.0
10	-7637.672	4210.090	0.0	0.0	0.0	0.0	0.0
11	-9621.758	3720.064	0.0	0.0	0.0	0.0	0.0
12	-11698.789	3344.663	0.0	0.0	0.0	0.0	0.0
13	-14109.164	2787.173	0.0	0.0	0.0	0.0	0.0
14	-14928.719	2342.580	0.0	0.0	0.0	0.0	0.0
15	-14721.598	1992.724	0.0	0.0	0.0	0.0	0.0
16	-12752.242	1730.361	0.0	0.0	0.0	0.0	0.0
17	-9945.207	1331.596	0.0	0.0	0.0	0.0	0.0
18	-5531.172	909.704	0.0	0.0	0.0	0.0	0.0
19	-1799.261	437.709	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CHORD BENDING MOMENT

STATION	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
0	-8804.473	8804.320	0.0	0.0	0.0	0.0	0.0
1	-6828.152	9180.082	0.0	0.0	0.0	0.0	0.0
2	377.258	11304.187	0.0	0.0	0.0	0.0	0.0
3	3722.599	9521.836	0.0	0.0	0.0	0.0	0.0
4	5262.352	8705.273	0.0	0.0	0.0	0.0	0.0
5	5916.012	8223.551	0.0	0.0	0.0	0.0	0.0
6	6348.727	7641.613	0.0	0.0	0.0	0.0	0.0
7	6407.707	7237.410	0.0	0.0	0.0	0.0	0.0
8	6254.047	6860.176	0.0	0.0	0.0	0.0	0.0
9	5759.895	6228.855	0.0	0.0	0.0	0.0	0.0
10	5103.738	5670.465	0.0	0.0	0.0	0.0	0.0
11	4251.316	5066.937	0.0	0.0	0.0	0.0	0.0
12	3372.738	4573.348	0.0	0.0	0.0	0.0	0.0
13	2087.275	3762.850	0.0	0.0	0.0	0.0	0.0
14	1075.675	3051.698	0.0	0.0	0.0	0.0	0.0
15	211.449	2334.671	0.0	0.0	0.0	0.0	0.0
16	-368.785	1580.513	0.0	0.0	0.0	0.0	0.0
17	-595.202	1009.979	0.0	0.0	0.0	0.0	0.0
18	-471.077	481.501	0.0	0.0	0.0	0.0	0.0
19	-200.792	151.731	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TORSION MOMENT

STATION	BLADE 1	BLADE 2	BLADE 3	BLADE 4	BLADE 5	BLADE 6	BLADE 7
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	-8587.641	-4504.066	0.0	0.0	0.0	0.0	0.0
3	-7927.887	-5141.105	0.0	0.0	0.0	0.0	0.0
4	-7504.070	-5675.047	0.0	0.0	0.0	0.0	0.0
5	-7242.437	-5720.074	0.0	0.0	0.0	0.0	0.0
6	-7120.074	-5662.926	0.0	0.0	0.0	0.0	0.0
7	-6859.676	-5634.281	0.0	0.0	0.0	0.0	0.0
8	-6554.484	-5622.367	0.0	0.0	0.0	0.0	0.0
9	-6027.926	-5674.566	0.0	0.0	0.0	0.0	0.0
10	-5362.484	-5667.539	0.0	0.0	0.0	0.0	0.0
11	-4864.066	-5564.734	0.0	0.0	0.0	0.0	0.0
12	-4424.168	-5414.570	0.0	0.0	0.0	0.0	0.0
13	-3985.173	-5180.016	0.0	0.0	0.0	0.0	0.0
14	-3663.824	-4721.742	0.0	0.0	0.0	0.0	0.0
15	-3500.042	-4277.305	0.0	0.0	0.0	0.0	0.0
16	-3353.245	-3720.653	0.0	0.0	0.0	0.0	0.0
17	-3071.152	-2950.427	0.0	0.0	0.0	0.0	0.0
18	-2519.440	-2151.601	0.0	0.0	0.0	0.0	0.0
19	-1523.911	-1243.403	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 70. Blade Element Bending Moment Data.

7. OUTPUT GUIDE FOR GDAP80

The outputs from the C81 postprocessor, Program GDAP80, are described in this section of the report. The user is referred to Section 6.1 for a description of the reference coordinate systems and to Section 6.2 for a description of the sign conventions used in these outputs.

The first outputs from the program are the data on the three comment cards input at the beginning of the AGAP80 deck, followed by the GDAP80 inputs for all the Postprocessing Data Blocks (PDB), as shown in Figure 71. The output for the analysis on a particular PDB is delimited from the output for the preceding PDB by a one-page message, as shown in Figure 72.

7.1 TIME-HISTORY PLOTS (Figure 73)

Time-history plots may be generated after time-variant trims, if $0 < XIT(5) < XIT(6)$, and after maneuvers, or both. The format of the two plots is almost identical.

7.1.1 Problem Identification

The same problem identification used for the trim pages (CARDS 02, 03, and 04) is used as the heading for the time-history plots. The words TRIM NO. and a number are printed below and to the left of these titles for plots after a TVT, and the word MANEUVER appears for time-history plots from the maneuver portion of the program.

7.1.2 Variables Plotted and Their Scales

The plot symbols used are the numbers 1, 2, and 4. The variables corresponding to each symbol and its units are printed as part of the plot heading. If two or all three of the curves intersect at a single point, the symbol printed is the sum of the individual symbols. For example, the symbol 7(= 1 + 2 + 4) means that all three curves pass through the point where the 7 is printed.

The lower and upper limits on the plot scale are given for each variable plotted. The scale in units per inch is also given.

7.1.3 General Comments

The user is cautioned that the automatic plot scaling procedure may expand small variations completely out of proportion to their true importance. Be certain to check the scales on all plots.

```
****
     42201 AH-1G + OLS ROTOR SIMULATION       AGAP80 ARMY VERSION
 OLS COUNTER 615, FLIGHT 35A, 2900* HP, 27 DEG C   (PAN NAME C818TRMT
 ELASTIC ROTOR, HSOFT = -17.0        OUTPUT TO GO INTO INPUT GUIDE
AGAP8001
****
14                                                                                  00112200
 3   1                                                                              00112300
   353   360   320     1                                        200.0               00112400
   367   374   320     1                                        200.0               00112500
   381   388   320     1                                        200.0               00112600
   395   402   320     1                                        200.0               00112700
   409  1508   320     1                                        200.0               00112800
  1509  1510   320     1                                        200.0               00112900
/1511   320            1                                 200.0                      00113000
 9               13        .925 1.296      0               0                        00113100
/ 353   360   367   374   381   388   395   402   409 1508 1509 1510 1511           00113200
12    1    1     1      1.111                                                       00113300
/    1    2                                                                         00113400
15    5    3                                                                        00113500
NEW SAMPLPRT PASS AUSTIN                                                            00113600
SPACE 9999 USER VG                                                                  00113700
RATE 256 RECORD 1.296                                                               00113800
ALL ITEMS ALL COUNTERS                                                              00113900
END                                                                                 00114000
 BBM1 CBM1 TBM1                                                                     00114100
/ 133   144   154   173   233   234   235   244   253   262   271   321             00114200
14                                                                                  00114300
 3   1                                                                              00114400
   353   360   320     1                                        200.0               00114500
   367   374   320     1                                        200.0               00114600
   381   388   320     1                                        200.0               00114700
   395   402   320     1                                        200.0               00114800
   409  1508   320     1                                        200.0               00114900
  1509  1510   320     1                                        200.0               00115000
/1511   320            1                                 200.0                      00115100
 9               13        .925 1.296      0               0                        00115200
/ 353   360   367   374   381   388   395   402   409 1508 1509 1510 1511           00115300
15    0    3                                                                        00115400
 BBM1 CBM1 TBM1                                                                     00115500
/ 133   144   154   173   233   234   235   244   253   262   271   321             00115600
14                                                                                  00115700
 3   1                                                                              00115800
   353   360   320     1                                        200.0               00115900
   367   374   320     1                                        200.0               00116000
   381   388   320     1                                        200.0               00116100
   395   402   320     1                                        200.0               00116200
   409  1508   320     1                                        200.0               00116300
  1509  1510   320     1                                        200.0               00116400
/1511   320            1                                 200.0                      00116500
 9               13        .925 1.296      0               0                        00116600
/ 353   360   367   374   381   388   395   402   409 1508 1509 1510 1511           00116700
15    0    3                                                                        00116800
 BBM1 CBM1 TBM1                                                                     00116900
/ 133   144   154   173   233   234   235   244   253   262   271   321             00117000
```

Figure 71. GDAP80 Input Listing.

```
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
THIS BLOCK OF DATA COMES FROM MR TVT   OF CASE NUMBER  2
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Figure 72. GDAP80 Case Delimiter.

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAPBOO1
COMPUTED 06/19/81

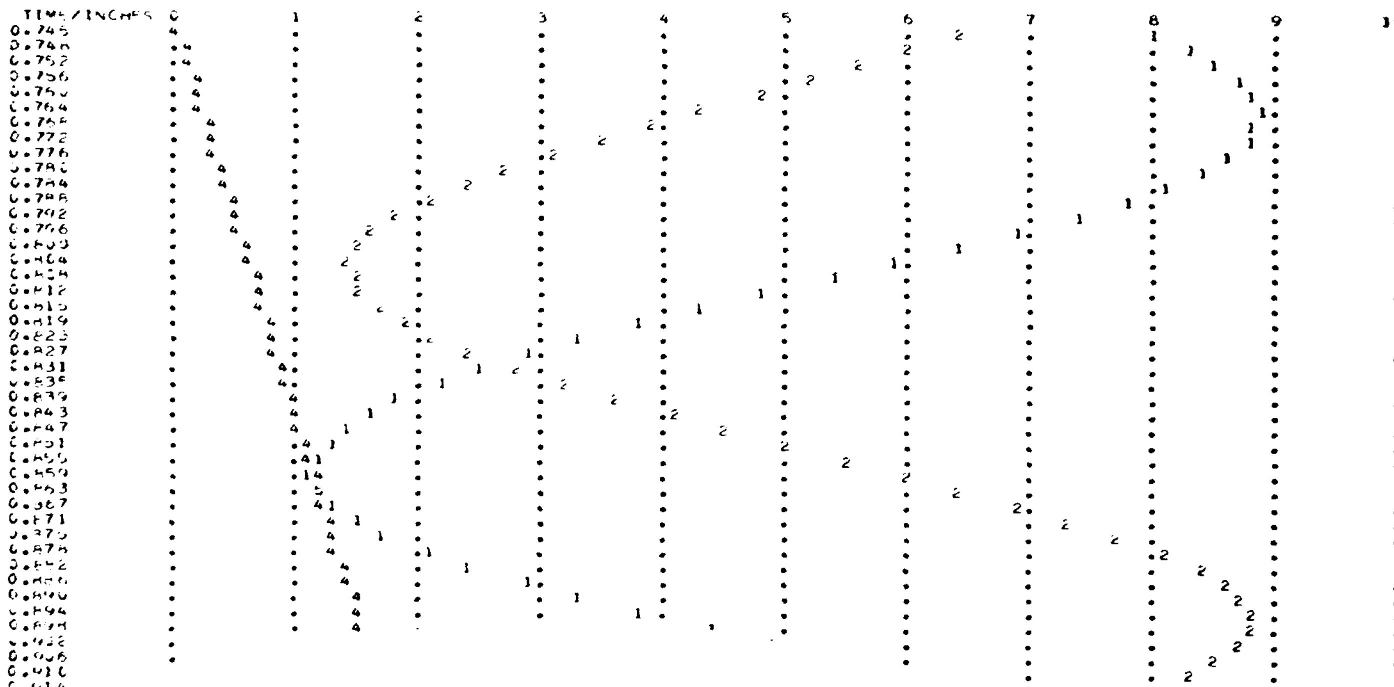
MR TVT OF CASE NUMBER 2 7 42201 AH-1G + ULS ROTOR SIMULATION AGAP80 ARMY VERSION
ULS COUNTER 615, FLIGHT 35A, 2900' HP, 27 DEG C (PAN NAME C818TRMT
ELASTIC ROTOR, HSOFT = -17.0 OUTPUT TO GO INTO INPUT GUIDE

SYMBOL 1 = GEN.COORD.,ROTOR 1,MODE 1,BLADE 1

SYMBOL 2 = GEN.COORD.,ROTOR 1,MODE 2,BLADE 1

SYMBOL 4 = ROTOR 1, AZIMUTH LOCATION, BLADE 1
DEGREES

SCALE	1	FROM	-1.000	TO	1.000.	1 INCH =	0.200	3 FOR 1 + 2		ON SAME PRINT POS.
SCALE	2	FROM	-0.100	TO	0.100.	1 INCH =	0.020	5 FOR 1 + 4		ON SAME PRINT POS.
SCALE	4	FROM	0.0	TO	2000.000.	1 INCH =	200.000	6 FOR 2 + 4		ON SAME PRINT POS.
								7 FOR 1 + 2	+ 4	ON SAME PRINT POS.



a) After time-variant trim.

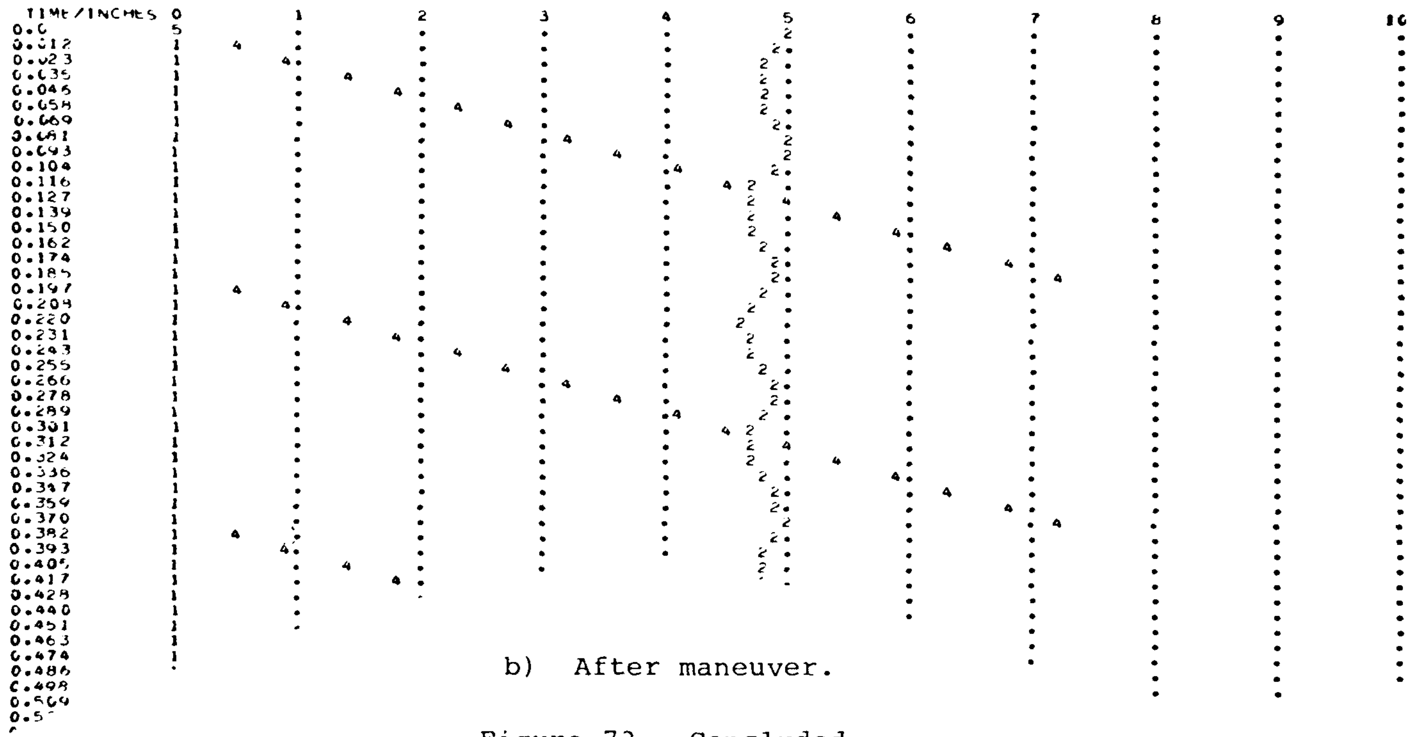
Figure 73. Sample Time-History Plot.

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP80G1
COMPUTED 06/19/81

MANEUVER OF CASE NUMBER 1   3   42202   AH-1G + OLS ROTOR SIMULATION AGAP80 ARMY VERSION
FLIGHT 32A, COUNTER 561, RIGHT ROLLING PULLOUT
ELASTIC ROTOR, NO RIVD (PAN NAME C81RMANT)

SYMBOL 1 = DESIRED ROLL RATE DEG/SEC
SYMBOL 2 = P VELOCITY, BODY AXES DEG/SEC
SYMBOL 4 = ROTOR 1, AZIMUTH LOCATION, BLADE 1 DEGREES

SCALE	1	FROM	0.0	TO	20.000,	1 INCH =	2.000	3 FOR 1 + 2	ON SAME PRINT POS.
SCALE	2	FROM	-25.000	TO	25.000,	1 INCH =	5.000	5 FOR 1 + 4	ON SAME PRINT POS.
SCALE	4	FROM	0.0	TO	500.000,	1 INCH =	50.000	6 FOR 2 + 4	ON SAME PRINT POS.
								7 FOR 1 + 2 + 4	ON SAME PRINT POS.



b) After maneuver.

Figure 73. Concluded.

Time is the independent variable, and is printed along the left edge of the plot, defining the time axis. For plots after TVT, time will not start at 0.0 if XIT(5) < XIT(6). Maneuver plots will always start at t = 0.0. If the time increment is changed at some point during a maneuver, there will be a change in the time scale at this point. The resulting compression or expansion of the time scale may cause apparent discontinuities that are not actually in the data. The user should check the time scale carefully.

Each plot card, Card 22, is independent of all other plot cards. Thus, if desired, one variable may be plotted on more than one plot. One example that has proved useful is rotor azimuth position. This variable will help in pointing out any change in time scale, as well as giving phase information.

The dots printed down the page are spaced at 1-inch intervals to make it easier to read the plot values by eye. They also provide reference lines to help see slower variations on long time histories.

It is recommended that the user avoid plotting periodic variables of approximately the same magnitude, with near-zero phase shifts, on the same plot, as it will be difficult to differentiate between the traces.

The plot routine can store the values of all plot variables for a maximum of 2000 time points. Should the user specify NPRINT = 1 on Card 21 for a particularly long maneuver, the program will keep internally doubling NPRINT until the total number of points to be plotted is less than or equal to 2000. In like manner, no more than 2000 points may be plotted from a TVT.

7.1.4 CALCOMP Plots

The names of the variables plotted appear at the top of each CALCOMP page along with their respective plot symbols. The vertical scales and the plots themselves are identified by the plot symbols.

The recommendation with respect to plotting similar periodic variables on the same plot also applies to CALCOMP plots. A maximum of 2500 time points may be plotted.

7.2 OUTPUT OF HARMONIC ANALYSIS ROUTINE (Figure 74)

This program option gives a harmonic analysis (frequency versus amplitude function) for selected variables from a set of maneuver data.

GEN.COORD..ROTOR 1.MODE 1.BLADE 1

FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE	FREQUENCY	AMPLITUDE
0.0	-0.5070101E-02	0.4367316E+02	0.1712007E-02	0.8734631E+02	0.9879952E-03
0.2729572E+01	0.1651654E-01	0.4640273E+02	0.1617990E-02	0.9007588E+02	0.9709301E-03
0.5459145E+01	0.7776701E+00	0.4913229E+02	0.1542990E-02	0.9280545E+02	0.9545269E-03
0.8188717E+01	0.1781614E-01	0.5186186E+02	0.1466429E-02	0.9553502E+02	0.9411478E-03
0.1091829E+02	0.9637650E-02	0.5459145E+02	0.1402487E-02	0.9826460E+02	0.9285316E-03
0.1364786E+02	0.7204693E-02	0.5732101E+02	0.1345655E-02	0.1009942E+03	0.9176838E-03
0.1637743E+02	0.6133609E-02	0.6005058E+02	0.1289560E-02	0.1037237E+03	0.9075888E-03
0.1910699E+02	0.3689039E-02	0.6278015E+02	0.1246675E-02	0.1064533E+03	0.8992723E-03
0.2183656E+02	0.3334005E-02	0.6550974E+02	0.1205249E-02	0.1091829E+03	0.8917372E-03
0.2456615E+02	0.2949209E-02	0.6823930E+02	0.1166092E-02	0.1119125E+03	0.8856368E-03
0.2729572E+02	0.3011021E-02	0.7096887E+02	0.1133816E-02	0.1146420E+03	0.8805087E-03
0.3002528E+02	0.2477727E-02	0.7369844E+02	0.1103395E-02	0.1173716E+03	0.8764649E-03
0.3275487E+02	0.2258634E-02	0.7642802E+02	0.1075309E-02	0.1201012E+03	0.8734132E-03
0.3548444E+02	0.2080943E-02	0.7915759E+02	0.1049918E-02	0.1228307E+03	0.8714676E-03
0.3821400E+02	0.1947682E-02	0.8188716E+02	0.1028012E-02	0.1255603E+03	0.8703051E-03
0.4094357E+02	0.1818880E-02	0.8461673E+02	0.1006591E-02		

Figure 74. Output of Harmonic Analysis Routine.

7.2.1 Printed Output

7.2.1.1 Variable Identification

An identifying phrase and units for the variable analyzed are printed at the head of each page of harmonic analysis data.

7.2.1.2 Frequency-Amplitude Table

The frequency and amplitude data are presented in three pairs of columns. The frequency is given in cycles per second, and the amplitude is in the units given in the heading.

7.2.2 CALCOMP Output

An amplitude-versus-frequency plot generated by the harmonic analysis routine consists of the tabulated points connected by straight-line segments. The zero value or steady component is always plotted as zero. The actual value is then given at the bottom of the page unless it is too big for the CALCOMP to handle. The variable identification with units is also given at the bottom of the page.

7.3 VECTOR ANALYSIS DATA (Figure 75)

This program option gives a vector analysis (least-squared-errors curve fit) of selected variables from a set of maneuver data.

7.3.1 Curve-Fit Analysis

7.3.1.1 Problem Identification

This output is the same as the headings printed for the trim page(s) and for time-history plots.

7.3.1.2 Curve-Fit Heading

The maneuver time at which the curve fit starts is given. All time points prior to this time are disregarded by the curve-fit procedure. The frequency used in the curve fit, OMEGA, is given in cycles per second. The curve-fit function, F(T), is expressed in general form:

F(T) = AMPLITUDE * SIN(OMEGA * T + PHASE ANGLE) + CONSTANT

(where T is time as measured during maneuver).

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001
COMPUTED 06/19/81

11 42202 AH-1G + OLS ROTOR SIMULATION AGAP80 ARMY VERSION
FLIGHT 32A, COUNTER 561, RIGHT ROLLING PULLOUT
ELASTIC ROTOR, NO RIVD (PAN NAME C818MANT)

LEAST SQUARES CURVE FIT STARTING AFTER 0.035 SECONDS MANEUVER TIME

F(T) = AMPLITUDE*SIN(OMEGA*T + PHASE ANGLE) + CONSTANT WITH OMEGA = 5.400 CPS

VARIABLE	AMPLITUDE	PHASE ANGLE (DEGREES)	CONSTANT	COEF OF CORR
ROTOR 1, THRUST POUNDS	49.111	-114.13	7718.9	.21395E-01
ROTOR 1, H-FORCE POUNDS	7.0223	106.63	267.01	.33762E-01
ROTOR 1, Y-FORCE POUNDS	9.4964	38.769	-211.47	.34390E-01

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001
COMPUTED 06/19/81

11 42202 AH-1G + OLS ROTOR SIMULATION AGAP80 ARMY VERSION
FLIGHT 32A, COUNTER 562, RIGHT ROLLING PULLOUT
ELASTIC ROTOR, NO RIVD (PAN NAME C818MANT)

AMPLITUDE AND PHASE ANGLE COMPARISONS

VARIABLES			AMPLITUDE RATIO	PHASE ANGLE DIFFERENCE
ROTOR 1, H-FORCE	POUNDS	/		
ROTOR 1, THRUST	POUNDS		.14299	220.76
ROTOR 1, Y-FORCE	POUNDS	/		
ROTOR 1, THRUST	POUNDS		.19341	152.90

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001
COMPUTED 06/19/81

11 42202 AH-1G + OLS ROTOR SIMULATION AGAP80 ARMY VERSION
FLIGHT 32A, COUNTER 561, RIGHT ROLLING PULLOUT
ELASTIC ROTOR, NO RIVD (PAN NAME C818MANT)

VARIABLE 'A' AS A LINEAR COMBINATION OF VARIABLES 'B' AND 'C'.

A = KB*B + KC*C + KD

VARIABLE	NAME		COEFFICIENT
A	ROTOR 1, Y-FORCE	POUNDS	
B	ROTOR 1, THRUST	POUNDS	-.27438
C	ROTOR 1, H-FORCE	POUNDS	-.94366
		CONSTANT	2158.4

Figure 75. Vector Analysis Data.

7.3.1.3 Variable, Amplitude, Phase Angle, and Constant

Below the general equation are five columns as follows:

(1) VARIABLE: In this column the variable being curve fit is identified, and its units are given.

(2) AMPLITUDE: This number may be substituted into the general equation for AMPLITUDE. The units are those given under VARIABLE.

(3) PHASE ANGLE: This number may be substituted into the general equation for PHASE ANGLE. The units are degrees, as labeled.

(4) CONSTANT: This quantity may also be substituted directly into the general equation. The units are those given under VARIABLE.

(5) COEF OF CORR: This denotes the coefficient of correlation and is a measure of how well the variable under consideration is fit by a sinusoidal variation at the frequency selected. A number greater than 0.95 in this column indicates a reasonably good fit. A smaller value is generally caused by other frequency content or a transient condition.

7.3.2 Amplitude and Phase Angle Comparisons

The problem identification is repeated at the top of the following page.

The magnitude and phase angles between variable vectors are compared for selected pairs of variables. The variables compared are labeled as VARIABLE A/VARIABLE B. The variable identifications used are the same as those used on the previous page and for the plot headings. The amplitude ratio printed is AMPLITUDE A divided by AMPLITUDE B. The phase angle difference is PHASE ANGLE A minus PHASE ANGLE B.

7.3.3 Variable "A" as a Linear Combination of Variables "B" and "C"

Following the amplitude and phase angle comparisons, the program skips to the top of the next page and again prints the problem identification heading.

If all the selected variables are viewed as vectors rotating at the same rotational speed, OMEGA, any one variable may be expressed as a linear combination of two other variables and as a constant as long as the phase angle between the two variables

is not 0 or 180 degrees. This relationship is given generally in the heading as A = KB * B + KC * C + KD.

Here A, B, and C are the variables concerned. The variable identification phrase is printed for each in the output. KB, KC, and KD are constants determined by the program and printed in the column labeled COEFFICIENT. In this row for variable B, the coefficient is KB; in the row for variable C, the coefficient is KC; and in the unlabeled variable row, which has the word CONSTANT to the right of the row, the coefficient is KD.

7.3.4 Time Used

The time used in the vector analysis process is printed along with the total elapsed computing time at the completion of the vector analysis routine.

7.4 STABILITY ANALYSIS DATA

The results of the Moving Block Fast Fourier Transform stability analysis (NPART = 6, 30-series cards) or the stability analysis using Prony's method (NPART = 13, 80-series cards) are printed out after the maneuver is completed. The output for each starts at the top of a new page with a heading giving the program title and run date, the value of NPART and the contents of cards 03, 04 and 05. The format of the remaining output is different for each type of analysis.

7.4.1 Moving Block Fast Fourier Transform (Figure 76)

A block of output is printed for each variable analyzed, with the first line of the block giving the variable name and its code number. The next three lines give the start and stop time for the analysis, the frequency range, and the number of cycles analyzed. (This is merely a recapitulation of the data input on the 32-type card.) The next two lines give the predominant frequency in the range of interest and the damping values for that response frequency.

7.4.2 Stability Analysis Using Prony's Method (Figure 77)

The results of the analysis of each variable are printed in a separate block with the variable name and code number printed in the first line. The second and third lines contain the start and stop time and the number of terms used in the curve fit of the variable in this time period, as requested on the 82-type card. The curve fit is of the form

$$v(t) = \sum_{j=1}^{jmax} \left(B_j e^{(\text{Real part})t} \; e^{i(\text{Imaginary Part})t} \right)$$

```
                              BELL HELICOPTER TEXTRON
                 ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP80C)
                              COMPUTED  06/19/81

     6          42202  AH-1G + OLS ROTOR SIMULATION  AGAP80 ARMY VERSION
                          FLIGHT 32A, COUNTER 561, RIGHT ROLLING PULLOUT
                          ELASTIC ROTOR, NO RIVD      (PAN NAME CR18MANT)

                                                                        VARIABLE CODE =  353

DAMPING DETERMINED BY MOVING BLOCK FFT FURGEN.COORD..ROTOR 1,MODE 1,BLADE 1
  TIME INTERVAL ANALYZED:        START:  0.185 SECONDS          STOP:  0.758 SECONDS
  FREQUENCY BAND ANALYZED:          3.400 HERTZ  TO      7.400 HERTZ
  NUMBER OF CYCLES ANALYZED IS    2
  ACTUAL FREQUENCY IS    5.237 HERTZ
  DAMPING EXPONENT IS   -0.45173 /SECOND  (NEGATIVE STABLE)     AND THE DAMPING IS  1.37274 % CRITICAL  (POSITIVE STABLE).
```

Figure 76. Output from Stability Analysis Using Moving Block Fast Fourier Transform.

BELL HELICOPTER TEXTRON
ROTORCRAFT FLIGHT SIMULATION PROGRAM AGARP001
COMPUTED 06/19/81

13 42262 AH-1G + OLS ROTOR SIMULATION AGARPG ARMY VERSION
FLIGHT 32A, COUNTER 561, RIGHT ROLLING PULLOUT
ELASTIC ROTOR, NO RIVD (PAN NAME C81HMAN1)

STABILITY ANALYSIS BY PRONY CURVE FIT METHOD FOR:
GEN.COORD..ROTOR 1.MODE 1.BLADE 1 VARIABLE CODE = 353

TIME INTERVAL ANALYZED: START: 0.185 SECONDS STOP: 1.111 SECONDS

?1 TERMS USED FOR THE CURVE FIT - - - USE EVERY 1 TH TIME POINT

ROOT NUMBER J	ABSOLUTE AMPLITUDE B(J)	REAL PART (/SEC)	IMAGINARY PART (RAD/SEC)	IMAGINARY PART (HZ)	IMAGINARY PART (PER REV)	PERCENT DAMPING	PHASE ANGLE (DEG)
1	0.1[illegible]663	-5.98	32.66	5.20	0.96	18.01	89.01
2	0.27146	0.50	34.48	5.49	1.02	-1.46	-34.72
3	0.02[illegible]86	-0.28	101.76	16.20	3.00	0.28	-154.94
4	0.00234	-0.50	170.21	27.09	5.02	0.30	103.01
5	0.00222	-3.30	240.57	38.29	7.09	1.37	-129.59
6	0.00349	-10.84	354.32	56.39	10.44	3.06	-165.82
7	0.0[illegible]35	-19.42	434.74	69.19	12.81	4.46	-150.54

Figure 77. Output from Stability Analysis Using Prony's Method.

The coefficients in this summation are tabulated versus j in the output. The "real part" is the damping term, and the percentage damping and phase angle for this value are computed and printed at the right-hand side of the tabulation. A negative damping percentage indicates an unstable term. The imaginary part is the frequency of oscillation of the term, and it is printed out in radians/second, hertz, and per-rev for the user's convenience.

7.5 CONTOUR PLOTS

The C81 contour plot option provides tabulations and digital contour plots of selected variables. The selection of the variables and the type of output is made using the 70-series cards, NPART=12 (see Sections 3.7 and 5.7).

The value of the variable is tabulated by radial station and azimuth if NVARA$\neq$0. The radial station is printed at the left end of the rows of data and the azimuth, in degrees, is printed at the top of the columns. See Figure 78.

The digital contour plot of a variable is printed if NVARB $\neq$ 0 (see Figure 79). The edge of the rotor disk is delineated by asterisks and blazes of asterisks divide the disk into 30-degree segments. The range of the value of the variable at a point on the disk is denoted by the symbol printed at that point, with the symbol key printed to the right of the plot. The plotting routine ignores a few of the largest and smallest values of the variable over the rotor disk and then divides the remaining range into 10 equal sub-ranges and assigns a symbol to each. Also, the plotting routine assumes that the radial stations are equally spaced. If unequal radial segmentation has been used, then the resulting plot will not be correct.

Note that a tabulation or contour plot of a variable on a time-variant rotor during a maneuver will, in general, show a discontinuity at the azimuth location at which the tabulation or plot begins. The azimuth just preceding that starting azimuth on the tabulation or on the plot corresponds to a time equal to one rotor revolution later.

If both NVARA and NVARB are other than zero, the tabulation for a particular variable precedes the contour plot.

7.6 CREATION OF A DATA TRANSFER FILE

The output generated during the creation of a Data Transfer File (NPART = 15, 90-series cards) is shown in Figure 80.

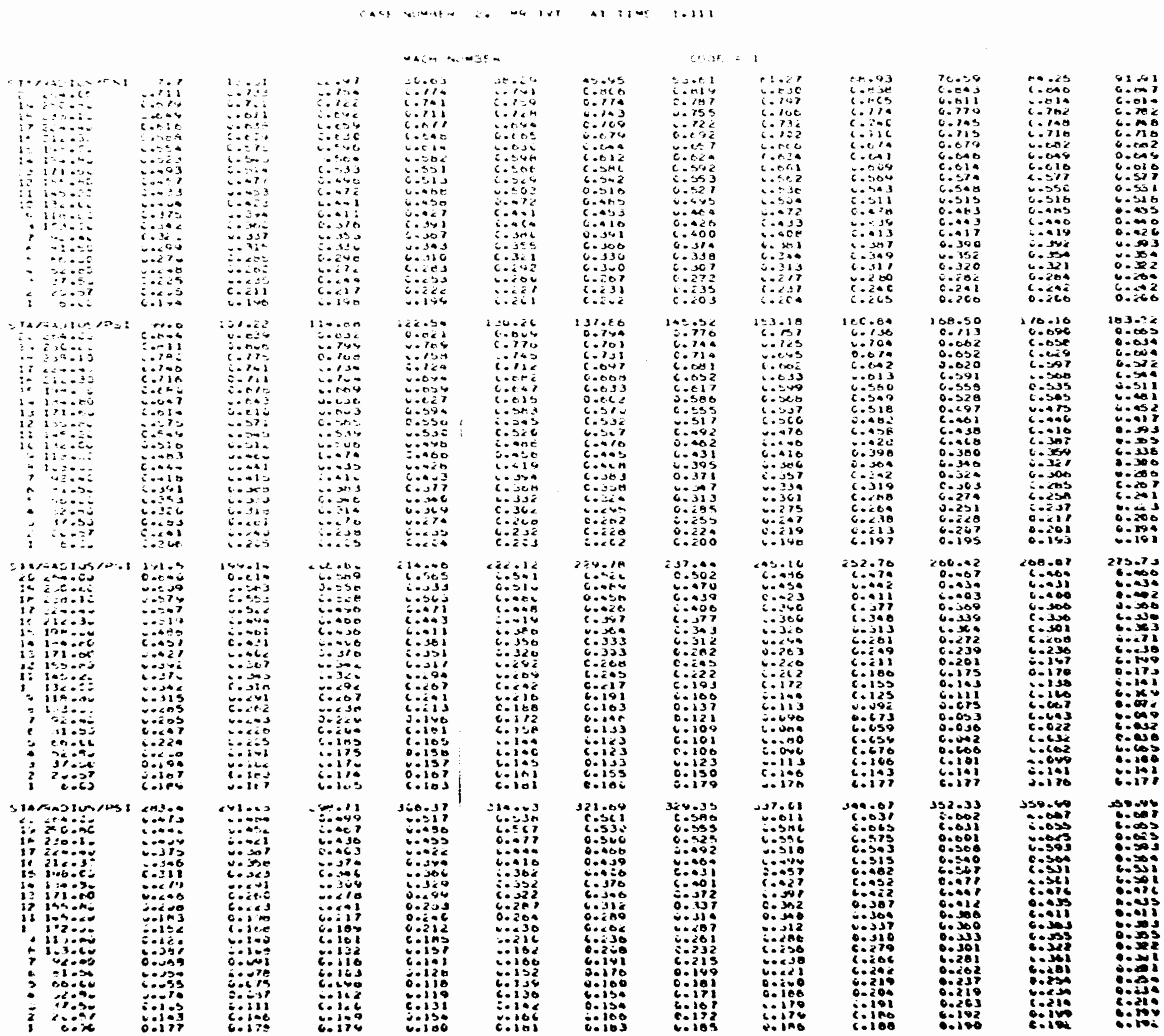
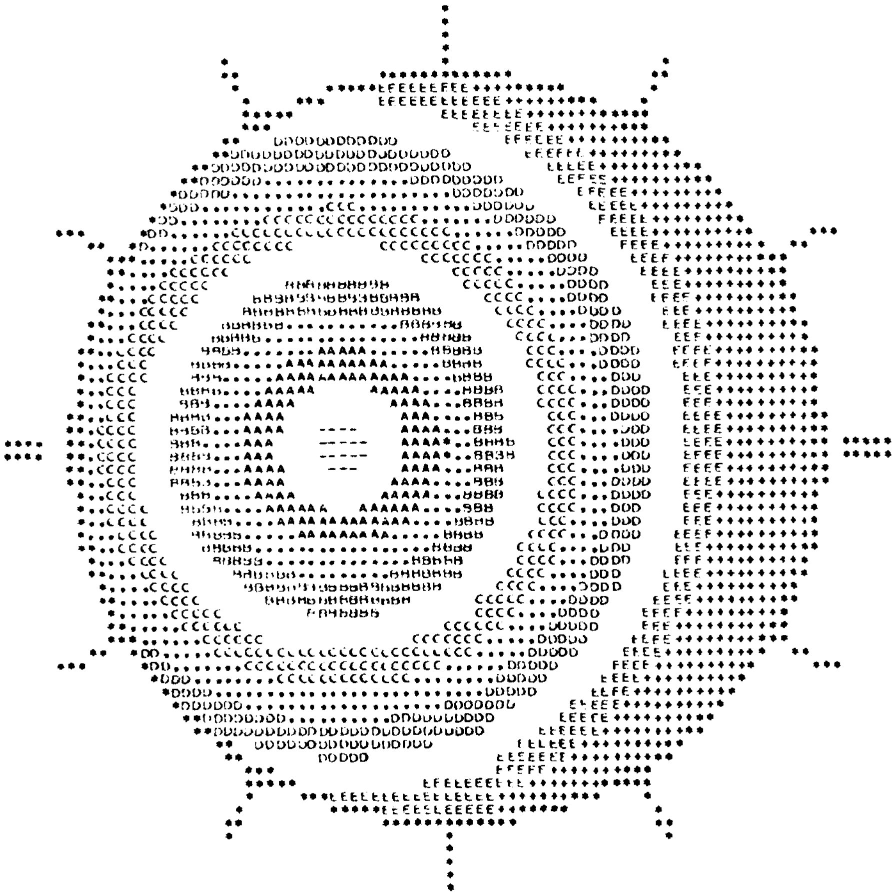


Figure 78. Data Tabulation from Contour Plot Option.

CASE NUMBER 2. MR TVT AT TIME 1.111

MACH NUMBER CODE = 1



SYMBOL	RANGE
-	< 0.052
	0.052 . . . < 0.115
A	0.115 . . . < 0.178
.	0.178 . . . < 0.241
B	0.241 . . . < 0.304
	0.304 . . . < 0.367
C	0.367 . . . < 0.430
.	0.430 . . . < 0.493
D	0.493 . . . < 0.556
	0.556 . . . < 0.619
E	0.619 . . . < 0.682
+	≥ 0.682

Figure 79. Rotor Contour Plot.

```
                         BELL HELICOPTER TEXTRON
                ROTORCRAFT FLIGHT SIMULATION PROGRAM AGAP8001
                           COMPUTED  06/19/81

  [illegible]        [illegible]  AH-1G + OLS ROTOR SIMULATION     AGAPRO ARMY VERSION
                     OLS COUNTER 615, FLIGHT 35A, 2900* HP, 27 DEG C   (PAN NAME C81BTRMT
                     ELASTIC ROTOR, HSOFT = -17.0       OUTPUT TO GO INTO INPUT GUIDE

A DATA TRANSFER FILE HAS BEEN CREATED FOR THIS RUN.

THERE ARE [illegible] INSTRUCTIONS FOR THIS RUN.

     NEW SAMPLE,[illegible] PASS AUSTIN
     [illegible]
     [illegible]
     ALL ITEMS ALL COUNTERS
     [illegible]

THE [illegible] FOR THIS CASE IS 165240

THERE ARE [illegible] GROUPS IN THE DTF. THEY ARE
     [illegible]

THERE ARE [illegible] ITEM CODES IN THE DTF. THEY ARE LISTED BELOW.

     ITEM CODE  DESCRIPTION - - - - - - - - - - - - - - - - - - - - - - - UNIT - GEN BY INFO FILE GRP

     [illegible]  RTR 1,BLD 1,STA  0, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  1, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  2, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  3, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  4, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  5, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  6, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  7, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  8, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  9, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 10, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 11, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 12, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 13, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 14, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 15, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 16, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 17, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 18, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 19, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA 20, BEAM BEND MOM                       IN-LB         BBM1
     [illegible]  RTR 1,BLD 1,STA  0, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  1, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  2, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  3, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  4, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  5, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  6, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  7, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  8, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  9, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 10, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 11, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 12, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 13, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 14, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 15, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 16, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 17, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 18, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 19, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA 20, CHRD BEND MOM                       IN-LB         CBM1
     [illegible]  RTR 1,BLD 1,STA  0, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  1, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  2, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  3, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  4, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  5, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  6, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  7, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  8, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA  9, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 10, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 11, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 12, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 13, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 14, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 15, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 16, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 17, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 18, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 19, TORS MOM                            IN-LB         TBM1
     [illegible]  RTR 1,BLD 1,STA 20, TORS MOM                            IN-LB         TBM1
     [illegible]  ROTOR 1, HORSEPOWER
     [illegible]  ROTOR 2, HORSEPOWER
     [illegible]   TOTAL HORSEPOWER REQUIRED
     [illegible]   TRUE AIR SPEED                                         KNOTS
     [illegible]   YAW ANGLE, FIXED/BODY                                  DEGREES
     [illegible]   PITCH ANGLE, FIXED/BODY                                DEGREES
     [illegible]   ROLL ANGLE, FIXED/BODY                                 DEGREES
     [illegible]   COLLECTIVE STICK POSITION                              PERCENTS
     [illegible]   F/A CYCLIC STICK POSITION                              PERCENTS
     [illegible]   LATERAL CYCLIC STICK POSITION                          PERCENTS
     [illegible]   PEDAL POSITION                                         PERCENTS
     [illegible]  ROTOR 1, FLAPPING,HUB/MAST,BLADE 1                      DEGREES
     [illegible]  ROTOR 1, AZIMUTH LOCATION, BLADE 1                      DEGREES
     [illegible]  ROTOR 2, AZIMUTH LOCATION, BLADE 1                      DEGREES
     TIME         SIMULATION TIME                                         SECONDS
```

Figure 80. Output from Generation of a Data Transfer File.

8. DIAGNOSTIC AND ERROR MESSAGES

8.1 GENERAL

All of the messages generated by the computer program itself rather than by the computer operating system are listed below. The messages are in strict alphabetical order.

Two or more words or phrases enclosed in brackets, one above the other, indicates that it is possible to have either word or phrase, but only one, in the message when it is printed out. An underline in the message indicates a place for a numerical value in the message.

Each message is followed by the name of the subroutine that printed it out. The next statement describes the condition that caused the message to be printed. Next is an indication of the consequences of the condition followed by instructions to the user.

8.2 MESSAGES

8.2.1 ABNORMALLY RETURNED FROM SUBROUTINE TVT SEE YOUR PROGRAMMER(S)

From TVTRIM

An error was encountered in TVTRIM. See your programmer(s).

Execution Terminates.

8.2.2 ALLEVIATION DEVICE FOR WINGS BYPASSED BECAUSE WING CHORD IS TOO SMALL FOR THIS TIME INCREMENT AND VELOCITY

From WAG

The analysis contained in WAG assumes that a minimum number of data points will be sampled in a distance traveled, which is calculated from the wing chord. This message indicates that the ratio, $V(\Delta t)/(\text{wing chord})$, is too large for the numerical procedure (message activated only during maneuver).

WAG is bypassed for wing. Execution continues.

To eliminate the message, make Δt (or $\Delta\Psi$) on data card 291 smaller.

8.2.3 AN ATTEMPT WAS MADE TO MANIPULATE A VARIABLE WHICH HAD NOT BEEN INCLUDED IN THE GROUP TO BE FITTED. PROCESSING TERMINATED

From CURVET

During the amplitude and phase angle comparison of the linearization portion of the curve-fit section of the program, a request was made to use a variable for which no prior request to fit that variable had been made. Thus, the necessary information had not been computed and so the comparison or linearization could not be made.

Comparison and linearization terminates.

Check input data to curve-fit routine for error indicated.

8.2.4 BANKED TURN WITH G LEVEL = ______

From TURN

Based on inputs for IPL(1) and XIT(66) a trim in a steady turn has been specified. This message is for information only.

8.2.5 CHANGE IN JET THRUST WITH $\left\{\begin{array}{l}\text{COLLECTIVE}\\ \text{F/A CYCLIC}\\ \text{LAT CYCLIC}\\ \text{PEDAL}\end{array}\right\}$ STICK POSITION

INPUT IS IN ERROR

From JFBGIN

The number of controlled jets, XJET(1), was input as zero, but the change in jet thrust with the specified control was not zero.

Problem step terminates.

Check the values of XJET(1), XCON(1), XCON(6), XCON(13), XCON(20), and XCON(27) for errors.

8.2.6 CHECK INPUT FUSELAGE INERTIAS. THE NUMBERS INPUT ARE PHYSICALLY IMPOSSIBLE AND CANNOT BE HANDLED BY THIS PROGRAM.

From MNEM or EXTORS

This message indicates that $I_X I_Z - I_{XZ}^2 = 0$, which is physically impossible.

Problem step terminates.

Change the input data for I_X, I_Z, or I_{XZ} for fuselage and stores.

8.2.7 CHECK PART 2 DATA CARD____________J CODE IS____________

From SIVAR or TIVAR

A value for J on 301-type card has been input for which an operation is not defined.

Problem step terminates.

Change the card indicated by the message.

8.2.8 COLLECTIVE STICK / F/A CYCLIC STICK / LAT CYCLIC STICK / PEDAL } POSITION EXCEEDS STOPS

(—— PERCENT FULL THROW COMPUTED)

From TRIM

The computed control position is beyond the input limits. Check these inputs and check to see that a realistic flight condition is being simulated.

8.2.9 COMPUTED CORRECTIONS EXCEEDED HALF PI

From ITRIM

A correction computed in the trim iteration procedure exceeds an angle of one-half radian. Check which correction is the largest and examine the most recently computed partial derivatives matrix to determine the cause.

Problem step terminates.

8.2.10 DATA ERROR . . . NPART = ______ _____

From MAIN

The control program, MAIN, read an incorrect value of NPART on CARD 01. This error most commonly occurs after another error has interrupted the normal sequence of events by terminating the problem step.

Problem step terminates.

8.2.11 DRAG DIVERGENCE MACH NUMBER INPUT FOR xxxx IS IN ERROR IT HAS BEEN RESET TO __________

Where xxxx is SUBGROUP 1, SUBGROUP 2, SUBGROUP 3, SUBGROUP 4, SUBGROUP 5, WING, STB1, STB2, STB3, or STB4

From YSINIT or YRINIT

Y(1) for rotor or surface aerodynamic data was input greater than or equal to 1. This is a warning message.

8.2.12 ERROR IN READING OR WRITING DATA FOR CONTOUR PLOTS.

From CONTOUR

This message indicates a JCL error or a hardware problem. Check with your local programmer. Contour plot task is terminated, execution of following tasks continues.

8.2.13 EXCESSIVE ANGLE OF ATTACK FOR N = $\left\{\begin{matrix}1\\2\end{matrix}\right\}$

From CDCL

The angle of attack of a blade segment on the $\left\{\begin{matrix}\text{main}\\\text{tail}\end{matrix}\right\}$ rotor exceeded 20 radians.

Problem step terminates.

8.2.14 EXCESSIVE ANGLE OF ATTACK ON = $\left\{\begin{array}{l}\text{STB1}\\ \text{STB2}\\ \text{STB3}\\ \text{STB4}\\ \text{RWG}\\ \text{LWG}\end{array}\right\}$

From CLCD

Subrouting CLCD was entered with the angle of attack of the

$\left\{\begin{array}{l}\text{Stabilizer No. 1}\\ \text{Stabilizer No. 2}\\ \text{Stabilizer No. 3}\\ \text{Stabilizer No. 4}\\ \text{Right Wing Panel}\\ \text{Left Wing Panel}\end{array}\right\}$ greater than 20 radians

Problem step terminates.

8.2.15 EXECUTION TERMINATED IN SUBROUTINE VIND. CONVERGENCE FAILURE FOR INDUCED VELOCITY. RESIDUE GREATER THAN .100 FT/SEC

From VIND

The thrust-induced velocity loop did not converge. Check to see that a realistic flight condition is being simulated.

8.2.16 F/A CYCLIC STICK POSITION EXCEEDS STOPS. (____PERCENT FULL THROW COMPUTED)

From TRIM

See Section 8.2.8.

8.2.17 FUSELAGE PITCH ANGLE IS 90 DEGREES

From FUSACC

The fuselage has reached a pitch angle that is singular for the Euler angle rotations. Check to see that a realistic flight condition is being simulated.

Program step terminates.

8.2.18 HUB TYPE AND MODE TYPES ARE INCONSISTENT IN THE INPUT TO $\begin{Bmatrix}\text{MAIN}\\ \text{TAIL}\end{Bmatrix}$ ROTOR

From INRO

The user is inputting independent modes for a teetering (gimbaled) rotor, or cyclic and collective modes for an articulated (or rigid) rotor. Check inputs.

Program step terminates.

8.2.19 INPUT FOR NO. OF ADVANCE RATIOS, __________, IS IN ERROR.

From REDRWK, REDSWK (preceded by STABILIZING SURFACE #______)

The input for the number of advance ratio entries in the rotor-induced velocity distribution table, or for a rotor-wake-at-surface table, is greater than 10, the maximum allowable.

Problem step terminates.

Check for mispunched input or reduce the input to 10 or less.

8.2.20 INPUT TO IPL(________) IS IN ERROR

From ERRCHK

IPL input indicated has an illegal value. Problem step terminates.

Check for mispunched input or refer to Section 4 to find the reason the input was interpreted as an error.

8.2.21 INPUT TO $\begin{Bmatrix}\text{MAIN}\\ \text{TAIL}\end{Bmatrix}$ BLADE WEIGHT, INERTIA OR FIRST MASS MOMENT IS IN ERROR.

From INBLDM

One of these inputs is inconsistent. Check inputs.

Program step terminates.

8.2.22 INPUT TO $\begin{Bmatrix}\text{MAIN}\\ \text{TAIL}\end{Bmatrix}$ ROTOR BLADE RADIAL STATION ______ IS IN ERROR.

From INBLD

The radial stations input for the rotor give a segment length less than or equal to zero. Check inputs.

Problem step terminates.

8.2.23 INPUT FOR NO. OF INFLOW RATIOS, _______, IS IN ERROR.

From REDSWK (Preceded by STABILIZING SURFACE #______)

The input for the number of inflow ratio entries in the rotor-wake-at-surface table, is greater than 5, the maximum allowable.

Problem step terminates.

Check for mispunched input or reduce the input to 5 or less.

8.2.24 INPUT FOR NO. OF RADIAL STATIONS IS ________ IN ERROR.

From REDRWK

The input for the number of radial station entries in the rotor-induced velocity distribution table is not equal to one of the values specified.

Problem step terminates.

Check for mispunched input or change the input to one of the prescribed values.

8.2.25 INPUT FOR THE HIGHEST HARMONIC __________ IS IN ERROR.

From REDRWK, REDSWK

The input for the number of the highest harmonic in the rotor-induced velocity distribution table is greater than 6.

Problem step terminates.

Check for mispunched input or reduce the input to 6 or less.

8.2.26 INPUTS TO CONTROL VARIABLES FOR USE OF AIRFOIL AERODYNAMIC TABLES OR EQUATIONS ARE IN ERROR.

From START

The value of Y(18) in the Rotor, Wing or Stabilizing Surface Aerodynamics groups was less than 0 or greater than 10. The value must be between 0 and 10.

Check inputs.

Program step terminates.

8.2.27 INPUT TO NUMBER OF TRANSFER FUNCTIONS REQUESTED HAS BEEN RESET TO 0. EXECUTION CONTINUES.

From LGCINT

Input for IPL(93) was outside the range -1 to 4. Recheck input for IPL(93). Execution continues with three standard transfer functions calculated for Stability Analysis.

8.2.28 INPUT TO RIVD TABLE IS IN ERROR. BLADE RADIAL STATION ________ IS AT _________.

From REDRWK

The radial stations input with the RIVD table do not agree with those input in the rotor group. Check inputs.

Problem step terminates.

Check inputs.

Program step terminates.

8.2.29 INPUT TO SWITCH FOR READING ROTOR CONTROL INPUTS IS IN ERROR

From XCONIN

The value of IPL(22) indicates that the rotor supplementary controls group is not to be read. However, other data indicates that the configuration being simulated is not a single-main-rotor helicopter. These situations are not compatible.

Problem step terminates.

Add the specified controls subgroup, using blank cards if the inputs are not to be used. Check location and orientation of rotors.

8.2.30 THE INPUT TO THE BREAKPOINT FOR NONLINEAR HUB SPRING IS IN ERROR. IT HAS BEEN RESET TO ZERO.

From INRO

The breakpoint for the nonlinear hub spring was input less than zero. The nonlinear hub spring rate is set to zero and execution continues.

8.2.31 INPUT TO WEIGHT OR TIME TO DROP EXTERNAL STORE NO. ____ IS IN ERROR.

From SIVAR

The time to drop the referenced store on a 301-type card is less than zero or the weight input, XSTi(1), for the referenced store (i) is less than or equal to zero. The weight input of a store/brake group must be greater than zero for a store which is to be dropped.

Problem step terminates.

Check inputs for time to drop store (J = 35) and weight of store to be dropped for input errors.

8.2.32 IPSN INDICATED NOT ON LIBRARY.

From C81L

In an operation with NPART = 8, NVARA $\neq$ 0 on Card 01, the IPSN input on card 02 does not match any IPSN on the file tape.

Problem step terminates.

Check input IPSN and list of IPSN's on the file tape.

8.2.33 LAT CYCLIC STICK POSITION EXCEEDS STOPS (______PERCENT FULL THROW COMPUTED)

From TRIM

See Section 8.2.8.

8.2.34 $\left\{\begin{matrix}\text{MAIN}\\ \text{TAIL}\end{matrix}\right\}$ ROTOR FLAPPING CORRECTION IS INFINITE.

From ITROT

The iteration loop in the rotor analysis that balances the rotor flapping moments was activated and could not compute a correction to the flapping angles.

Problem step terminates.

Check configuration, flight regime, and spatial orientation for compatibility.

8.2.35 $\begin{Bmatrix} \text{MAIN} \\ \text{TAIL} \end{Bmatrix}$ ROTOR FLAPPING MOMENT IS NOT IN BALANCE AFTER _______________ ITERATIONS.

From ITROT

The iteration loop in the rotor analysis that balances the rotor flapping moments was activated but could not balance the rotor in the number of iterations allowed.

Problem step terminates.

Check configuration, flight regime, and spatial orientation for compatibility.

8.2.36 $\begin{Bmatrix} \text{MAIN} \\ \text{TAIL} \end{Bmatrix}$ ROTOR HAS ZERO DETERMINANT IN THE COMPUTATION OF EQUIVALENT MASS DISTRIBUTION.

From INBMSS

When the rotor is not represented by normal modes, the mass distribution is determined from the blade weight, first mass moment, and second mass moment of inertia. This error message indicates that the three values input for the indicated rotor are incompatible.

Check inputs.

Problem step terminates.

8.2.37 $\begin{Bmatrix} \text{MAIN} \\ \text{TAIL} \end{Bmatrix}$ ROTOR INERTIA = __________ SLUG - FT ** 2

From INRO

When a rotor is represented by a set of mode shapes, this message is printed to give the computed inertia. It is not an error message unless the computed inertia is less than zero. In that case, check the input mass distribution.

When the rotor is not represented by a set of mode shapes, then the rotor inertia is input by XMR(12) or XTR(12). This message is printed if either of these is less than zero. Check your inputs.

Problem step terminates if the inertia is less than zero.

8.2.38 $\left\{\begin{matrix}\text{MAIN}\\\text{TAIL}\end{matrix}\right\}$ ROTOR RADIUS HAS BEEN RESET TO THE LAST VALUE OF THE BLADE RADIAL STATION DISTRIBUTION.

From INBLD

Warning message. The input for rotor radius based on the segment lengths is not the same as the value of XMR(4) or XTR(4). XMR(4) or XTR(4) is changed to agree with the segment data in the blade aeroelastic data group.

8.2.39 MEMBER __________ NOT IN C81LIB

From REDID

An attempt was made to read a data group from the data library, and the group was not on the library. Problem step terminates.

Check data for a misspelled group name, or if the member printed on the message appears to be data, check for extra or missing data cards.

8.2.40 NO TVT PLOTS. INPUT TO NO. OF REVS TO BE PLOTTED DURING TVT WAS__________

From TRIM

XIT(5) was either less than or equal to zero or greater than XIT(6), so no time history plots can be produced following the TVT. Execution continues.

8.2.41 THE PARTIAL DERIVATIVE MATRIX IS SINGULAR. THIS IS PROBABLY CAUSED BY ONE OF THE CONTROLS BEING UNCONNECTED.

From ITRIM

During the TRIM procedure, a singular partial derivative matrix occurred. The usual cause is an error in the input data for one of the controls. Previous matrices, if any, should be examined for a near-zero row or column to help locate the cause.

Problem step terminates.

8.2.42 PEAK FORCE/MOMENT OR ITS CORRESPONDING ANGLE INPUT FOR FUSELAGE

$$\left\{\begin{array}{l} \text{LIFT} \\ \text{PITCH} \\ \text{SIDE FRC} \\ \text{ROLL} \\ \text{YAW} \end{array}\right\} \quad \text{EQUATION IS IN ERROR}$$

IT HAS BEEN RESET TO 0.

From FUSINT

According to the inputs to the fuselage High Angle Equations a nonzero peak force or moment occurs at a zero aerodynamic angle or a zero peak force or moment occurs at a nonzero aerodynamic angle. The peak force or moment and the angle have been reset to zero. Based on the equation indicated, check the following fuselage inputs.

LIFT:	YFS(3) and YFS(4)
PITCH:	YFS(31) and YFS(32)
SIDE FORCE:	YFS(44) and YFS(45)
ROLL:	YFS(58) and YFS(59)
YAW:	YFS(72) and YFS(73)

Warning message only. Execution continues.

8.2.43 THE PHASE ANGLE DIFFERENCE BETWEEN _______ AND _______ IS A MULTIPLE OF 180 DEGREES. THEREFORE, NO VARIABLE CAN BE EXPRESSED AS A LINEAR FUNCTION OF THEM.

From CURVET

The vector analysis section of the program where the coefficients in the expression A = KB * B + KC * C + D are derived has failed because of the linear dependency of B and C.

Program goes to next set of variables.

8.2.44 PEDAL POSITION EXCEEDS STOPS (________ PERCENT FULL THROW COMPUTED)

From TRIM

See Section 8.2.8.

8.2.45 PULL-UP WITH G-LEVEL = ______

From TURN

Inputs for IPL(1) and XIT(66) have indicated a trim in a symmetric pullup with the g-level specified. This message is for information only.

8.2.46 PUSH-OVER WITH G-LEVEL = _______

From TURN

Inputs for IPL(1) and XIT(66) have indicated a trim in a symmetric pushover with the g-level specified. This message is for information only.

8.2.47 RATIO APPLIED TO CORRECTION VECTOR IS _____________ FROM COMPONENT ______.

From NCDAMP

During the trim iteration procedure, the calculated corrections exceeded the limits. All of the corrections have been multiplied by the printed ratio that was determined by setting the largest correction equal to its limit. The component is the column number of the largest correction.

8.2.48 ROTOR ________ INDUCED VELOCITY NOT CONVERGED TO .0001 FT/SEC; DELTA IS __________; VALUE USED IS ___________

From VIND

The induced velocity calculated for the indicated rotor has not converged in the thrust-induced velocity calculations. The value subsequently used is given.

This is a warning message only. Execution continues.

8.2.49 ... SHIP CONTACTS GROUND

From VIND

Altitude, XFC(4), has become negative.

Problem step terminates.

Find out why ship lost altitude and correct.

8.2.50 SINGULAR MATRIX ENCOUNTERED IN STABILITY ANALYSIS AT M = __________

From INTFRQ

Problem terminates. Check with the local programmer.

8.2.51 SINGULAR MATRIX ENCOUNTERED IN SUBR. SOLVE

From SOLVE

Problem terminates. Check with the local programmer.

8.2.52 $\left\{\begin{array}{l} \text{STB1} \\ \text{STB2} \\ \text{STB3} \\ \text{STB4} \\ \text{RWG} \\ \text{LWG} \end{array}\right\} \left\{\begin{array}{l} \text{ENTERING} \\ \text{LEAVING} \end{array}\right\}$ STALL

From CLCD

The angle of attack of one of the fixed aerodynamic surfaces has just crossed the stall point in the direction indicated. For information only.

8.2.53 THE START TIME __________ SECONDS IS GREATER THAN THE LAST TIME POINT ON THE TAPE _____ SECONDS.

From MOVBLK

The start time input on the NPART = 6 card is after the final time point of the time-history record. This is a probable input error. This NPART = 6 card is skipped. Execution continues.

8.2.54 STORE NO._____HAS BEEN DROPPED.

Followed by new values of weight, stationline, buttline, and waterline of the cg, and aircraft inertias.

From EXTORS. For information only.

8.2.55 SUPERSONIC MACH NUMBER FOR xxxx IS IN ERROR. IT HAS BEEN RESET TO ____________.

Where xxxx is SUBGROUP 1, SUBGROUP 2, SUBGROUP 3, SUBGROUP 4, SUBGROUP 5, WING, STB1, STB2, STB3, or STB4.

From YRNIT or YSINIT.

Y(2) was input less than or equal to 1.

This is a warning message. Execution continues.

8.2.56 TAIL ROTOR FLAPPING CORRECTION IS INFINITE

From ITROT

See Section 8.2.34.

8.2.57 TAIL ROTOR FLAPPING MOMENT IS NOT IN BALANCE AFTER
______________ ITERATIONS.

From ITROT

See Section 8.2.35.

8.2.58 TAIL ROTOR HAS ZERO DETERMINANT IN THE COMPUTATION OF EQUIVALENT MASS DISTRIBUTION.

From INBLDM

See Section 8.2.36.

8.2.59 TAIL ROTOR INERTIA = __________ SLUG-FT ** 2

From INRO

See Section 8.2.37

8.2.60 *THERE ARE NOT ENOUGH POINTS AVAILABLE FOR HARMONIC* ANALYSIS.

From FSFT

Either the maneuver record is too short or the time increments are too large to generate the data needed for the harmonic analysis (NPART = 9). The harmonic analysis is skipped. Any following tasks are executed as usual.

8.2.61 THE TIME HISTORY DOES NOT CONTAIN ___ CYCLES FOR VARIABLE ___ TO DO MOVING BLOCK ANALYSIS. THE MAX NO. OF CYCLES HAS BEEN CHANGED TO ___.

From MOVBLK

The time-history record is too short to have the number of cycles requested at the frequency requested for the moving block stability analysis (NPART=6). The program calculates the maximum number of cycles available and uses that value as printed. If the maximum number of cycles is two or less, the moving block analysis for this variable ends; execution for other variables or tasks continues.

8.2.62 TIME-VARIANT ROTORS CANNOT BE USED IN A STABILITY ANALYSIS.

From INSTAB

An attempt was made to enter the rotorcraft stability analysis routines with a time-variant rotor. The rotorcraft stability analysis is predicated upon using the quasistatic rotor analysis.

Program execution is terminated.

Either use the quasistatic rotor analysis, or eliminate the request for a rotorcraft stability analysis.

8.2.63 THE TIME-VARIANT TRIM HAS BEEN TURNED OFF IN THE STABILITY ANALYSIS.

From ERRCHK

Warning message that for a stability analysis case (NPART = 7), IPL(49) was input as nonzero requesting a time-variant trim. IPL(49) is reset to zero and the stability analysis is run as requested.

8.2.64 ** TOTAL POWER REQUIRED EXCEEDS TOTAL AVAILABLE. TRIM CONTINUES.

From WRTMNV

Power required for trim condition exceeds the input power available. Execution continues.

8.2.65 TYPE OF MANEUVERS ARE MIXED UP. EXECUTION TERMINATED.

From MANTYP

On CARDS 301 the J values include 101, 102, and/or 103 along with the standard values. It is not permitted to run maneuver perturbations and other maneuver inputs at the same time.

8.2.66 WARNING, THE PARTIAL DERIVATIVE MATRIX MAY BE IN ERROR.

From ITROT

In the rotor analysis, the iteration loop that balances the rotor flapping moments and the thrust-induced velocity iteration loop are both activated. While each is able to converge separately, they have not been able to converge together.

Warning message only. Execution continues.

Exercise care in use of the partial derivative matrix immediately following this message.

8.2.67 WEIGHT INPUT FOR DRAG BRAKE NO. _______ IS IN ERROR.

From SIVAR

This message indicates that a nonzero brake deployment (XSTi(14) > 0) has been input for a store/brake group that has a positive weight (XSTi(1) > 0), which is the correct input for a store. Check the inputs for the indicated store/brake group and make these two inputs consistent.

Problem step terminates.

8.2.68

$$\begin{Bmatrix} Y(22) \\ Y(23) \\ Y(24) \end{Bmatrix} \text{ FOR xxxx HAS BEEN RESET TO } \begin{Bmatrix} -1. \\ 0. \\ 0. \end{Bmatrix}$$

Where xxxx is SUBGROUP 1, SUBGROUP 2, SUBGROUP 3, SUBGROUP 4, SUBGROUP 5, WING, STB1, STB2, STB3, or STB4.

From YRINIT or YSINIT

The data input for the pitching moment coefficient was inconsistent and the adjustment indicated was made to make the data consistent.

Warning message only. Execution continues.

8.2.69 ZERO DEMONINATOR ENCOUNTERED WHEN ATTEMPTED TO CALCULATE $\begin{Bmatrix} \text{MAIN} \\ \text{TAIL} \end{Bmatrix}$ BLADE FLAPPING OR CYCLIC INCREMENTS.

From MBAL

Cramer's rule is used to solve for the flapping or cyclic increments in the rotor balancing iterations during trim. This error occurs when the denominator, which is the determinant of the coefficient matrix for the two flapping equations, is zero (i.e., the two equations are not independent). Check the rotor and controls inputs for consistency.

Problem step terminates.

9. VARIABLES SAVED DURING TIME-VARIANT TRIMS AND MANEUVER

The values of over 2300 variables are saved at each time point during a maneuver simulation, and may be saved for XIT(5) rotor revolutions during a time-variant trim. The program can perform one or more of the following operations on these data.

(1) Plotting (see Section 3.2)
(2) Stability Analysis (see Section 3.3)
(3) Harmonic Analysis (see Section 3.5)
(4) Vector Analysis (see Section 3.6)

As noted in the referenced sections, code numbers are used to identify the variable(s) to be plotted or analyzed. The code number for each variable saved is given in Table 28.

The variables saved can be grouped into the six general classifications given below:

Range of Code Numbers	Source or Type of Data
1 - 132	Force and moment summary
133 - 345	Trim or maneuver time point page
346 - 485	Elastic response of Rotor 1
486 - 625	Elastic response of Rotor 2
626 - 1066	Blade element moment data for Rotor 1
1067 - 1507	Blade element moment data for Rotor 2
1508 - 1539	Elastic pylon data
1540 - 1563	Rotor pitch link loads
1564 - 1575	Pylon accelerations
1576 - 2100	Rotor 1 aerodynamic quantities
2101 - 2625	Rotor 2 aerodynamic quantities
2626 - 2630	Autopilot inputs
2631 - 2643	Filter outputs
2644 - 2649	Accelerations at specified airframe location

The code numbers marked "Not used" are reserved for future additions to the list of variables saved and do not contain any meaningful data.

The code numbers for the bending moments and accelerations at each blade station of blade 1 of rotor 1 are given in Table 29.

TABLE 28. CODE NUMBERS FOR VARIABLES SAVED DURING TIME-VARIANT TRIM AND MANEUVER.

NUMBER	DESCRIPTION	UNITS
1	TOTAL X-FORCE ON C.G.	POUNDS
2	X-FORCE FROM RIGHT WING	POUNDS
3	X-FORCE FROM LEFT WING	POUNDS
4	NOT USED	
5	NOT USED	
6	X-FORCE FROM FUSELAGE	POUNDS
7	X-FORCE FROM JETS/GUN FIRE	POUNDS
8	X-FORCE FROM ROTOR1	POUNDS
9	X-FORCE FROM ROTOR2	POUNDS
10	X-FORCE FROM WEIGHT	POUNDS
11	TOTAL Y-FORCE ON C.G.	POUNDS
12	NOT USED	
13	Y-FORCE FROM FUSELAGE	POUNDS
14	Y-FORCE FROM JETS/GUN FIRE	POUNDS
15	Y-FORCE FROM ROTOR1	POUNDS
16	Y-FORCE FROM ROTOR2	POUNDS
17	Y-FORCE FROM WEIGHT	POUNDS
18	TOTAL Z-FORCE ON C.G.	POUNDS
19	Z-FORCE FROM RIGHT WING	POUNDS
20	Z-FORCE FROM LEFT WING	POUNDS
21	NOT USED	
22	Z-FORCE FROM FUSELAGE	POUNDS
23	Z-FORCE FROM JETS/GUN FIRE	POUNDS
24	Z-FORCE FROM ROTOR1	POUNDS
25	Z-FORCE FROM ROTOR2	POUNDS
26	Z-FORCE FROM WEIGHT	POUNDS
27	TOTAL ROLL MOM ON C.G.	FT-LB
28	ROLL MOM FROM RIGHT WING	FT-LB
29	ROLL MOM FROM LEFT WING	FT-LB
30	NOT USED	
31	NOT USED	
32	ROLL MOM FROM FUSELAGE	FT-LB
33	ROLL MOM FROM JETS/GUN FIRE	FT-LB
34	ROLL MOM FROM ROTOR1 FORCES	FT-LB
35	ROLL MOM FROM ROTOR2 FORCES	FT-LB
36	ROLL MOM FROM ROTOR1 TORQUE	FT-LB
37	ROLL MOM FROM ROTOR2 TORQUE	FT-LB
38	TOTAL PITCH MOM ON C.G.	FT-LB
39	PITCH MOM FROM RIGHT WING	FT-LB
40	PITCH MOM FROM LEFT WING	FT-LB
41	NOT USED	
42	NOT USED	
43	PITCH MOM FROM FUSELAGE	FT-LB
44	PITCH MOM FROM JETS/GUN FIRE	FT-LB
45	PITCH MOM FROM ROTOR1 FORCES	FT-LB
46	PITCH MOM FROM ROTOR2 FORCES	FT-LB
47	PITCH MOM FROM ROTOR1 TORQUE	FT-LB
48	PITCH MOM FROM ROTOR2 TORQUE	FT-LB
49	TOTAL YAW MOM ON C.G.	FT-LB
50	YAW MOM FROM RIGHT WING	FT-LB
51	YAW MOM FROM LEFT WING	FT-LB
52	NOT USED	
53	NOT USED	
54	YAW MOM FROM FUSELAGE	FT-LB
55	YAW MOM FROM JETS/GUN FIRE	FT-LB
56	YAW MOM FROM ROTOR1 FORCES	FT-LB
57	YAW MOM FROM ROTOR2 FORCES	FT-LB
58	YAW MOM FROM ROTOR1 TORQUE	FT-LB
59	YAW MOM FROM ROTOR2 TORQUE	FT-LB
60	X-FORCE FROM STABILIZER 1	POUNDS

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
61	X-FORCE FROM STABILIZER 2	POUNDS
62	X-FORCE FROM STABILIZER 3	POUNDS
63	X-FORCE FROM STABILIZER 4	POUNDS
64	Y-FORCE FROM STABILIZER 1	POUNDS
65	Y-FORCE FROM STABILIZER 2	POUNDS
66	Y-FORCE FROM STABILIZER 3	POUNDS
67	Y-FORCE FROM STABILIZER 4	POUNDS
68	Z-FORCE FROM STABILIZER 1	POUNDS
69	Z-FORCE FROM STABILIZER 2	POUNDS
70	Z-FORCE FROM STABILIZER 3	POUNDS
71	Z-FORCE FROM STABILIZER 4	POUNDS
72	NOT USED	
73	NOT USED	
74	NOT USED	
75	ROLL MOM FROM STAB NO. 1	FT-LB
76	ROLL MOM FROM STAB NO. 2	FT-LB
77	ROLL MOM FROM STAB NO. 3	FT-LB
78	ROLL MOM FROM STAB NO. 4	FT-LB
79	PITCH MOM FROM STAB NO. 1	FT-LB
80	PITCH MOM FROM STAB NO. 2	FT-LB
81	PITCH MOM FROM STAB NO. 3	FT-LB
82	PITCH MOM FROM STAB NO. 4	FT-LB
83	YAW MOM FROM STAB NO. 1	FT-LB
84	YAW MOM FROM STAB NO. 2	FT-LB
85	YAW MOM FROM STAB NO. 3	FT-LB
86	YAW MOM FROM STAB NO. 4	FT-LB
87	NOT USED	
88	NOT USED	
89	NOT USED	
90	Y-FORCE FROM RIGHT WING	POUNDS
91	Y-FORCE FROM LEFT WING	POUNDS
92	NOT USED	
93	NOT USED	
94	NOT USED	
95	NOT USED	
96	NOT USED	
97	NOT USED	
98	NOT USED	
99	NOT USED	
100	NOT USED	
101	NOT USED	
102	NOT USED	
103	NOT USED	
104	X-FORCE FROM STORE NO. 1	POUNDS
105	X-FORCE FROM STORE NO. 2	POUNDS
106	X-FORCE FROM STORE NO. 3	POUNDS
107	X-FORCE FROM STORE NO. 4	POUNDS
108	Y-FORCE FROM STORE NO. 1	POUNDS
109	Y-FORCE FROM STORE NO. 2	POUNDS
110	Y-FORCE FROM STORE NO. 3	POUNDS
111	Y-FORCE FROM STORE NO. 4	POUNDS
112	Z-FORCE FROM STORE NO. 1	POUNDS
113	Z-FORCE FROM STORE NO. 2	POUNDS
114	Z-FORCE FROM STORE NO. 3	POUNDS
115	Z-FORCE FROM STORE NO. 4	POUNDS
116	ROLL MOM FROM STORE NO. 1	FT-LB
117	ROLL MOM FROM STORE NO. 2	FT-LB
118	ROLL MOM FROM STORE NO. 3	FT-LB
119	ROLL MOM FROM STORE NO. 4	FT-LB
120	PITCH MOM FROM STORE NO. 1	FT-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
121	PITCH MOM FROM STORE NO. 2	FT-LB
122	PITCH MOM FROM STORE NO. 3	FT-LB
123	PITCH MOM FROM STORE NO. 4	FT-LB
124	YAW MOM FROM STORE NO. 1	FT-LB
125	YAW MOM FROM STORE NO. 2	FT-LB
126	YAW MOM FROM STORE NO. 3	FT-LB
127	YAW MOM FROM STORE NO. 4	FT-LB
128	NOT USED	
129	NOT USED	
130	NOT USED	
131	NOT USED	
132	NOT USED	
133	ROTOR 1. HORSEPOWER	
134	ROTOR 1. TORQUE	FT-LB
135	ROTOR 1. RPM	RPM
136	ROTOR 1. TIP SPEED	FT/SEC
137	ROTOR 1. ADV BLADE MACH NUMBER	
138	NOT USED	
139	RIGHT JET	POUNDS
140	NOT USED	
141	C.G. STATION LINE LOCATION	INCHES
142	C.G. BUTT LINE LOCATION	INCHES
143	C.G. WATER LINE LOCATION	INCHES
144	ROTOR 2. HORSEPOWER	
145	ROTOR 2. TORQUE	FT-LB
146	ROTOR 2. RPM	RPM
147	ROTOR 2. TIP SPEED	FT/SEC
148	ROTOR 2. ADV BLADE MACH NUMBER	
149	NOT USED	
150	LEFT JET THRUST	POUNDS
151	HORSEPOWER SUPPLIED	
152	ENGINE TORQUE SUPPLIED	FT-LB
153	ENGINE RPM	RPM
154	TOTAL HORSEPOWER REQUIRED	
155	TORQUE REQUIRED	FT-LB
156	X-COMP GUST VEL., BODY AXES	FT/SEC
157	U VELOCITY, BODY AXES	FT/SEC
158	V VELOCITY, BODY AXES	FT/SEC
159	W VELOCITY, BODY AXES	FT/SEC
160	P VELOCITY, BODY AXES	DEG/SEC
161	Q VELOCITY, BODY AXES	DEG/SEC
162	R VELOCITY, BODY AXES	DEG/SEC
163	COLLEC. BOBWT. VELOCITY	DEG/SEC
164	Y-COMP GUST VEL., BODY AXES	FT/SEC
165	U-DOT ACCEL., BODY AXES	FT/SEC/SEC
166	V-DOT ACCEL., BODY AXES	FT/SEC/SEC
167	W-DOT ACCEL., BODY AXES	FT/SEC/SEC
168	P-DOT ACCEL. BODY AXES	DEG/SEC/SEC
169	Q-DOT ACCEL. BODY AXES	DEG/SEC/SEC
170	R-DOT ACCEL. BODY AXES	DEG/SEC/SEC
171	COLLEC. BOBWT. ACCEL.	DEG/SEC/SEC
172	Z-COMP GUST VEL., BODY AXES	FT/SEC
173	TRUE AIR SPEED	KNOTS
174	GROUND SPEED	KNOTS
175	RATE OF CLIMB	FT/SEC
176	STAB NO. 1 ANGLE OF INCIDENCE	DEGREES
177	STAB NO. 1 FLAP ANGLE	DEGREES
178	STAB NO. 1 LIFT COEFFICIENT	
179	STAB NO. 1 DRAG COEFFICIENT	
180	STAB NO. 1 PITCHING MOMENT COEF	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
181	STAB NO. 1 ANGLE OF ATTACK	DEGREES
182	STAB NO. 1 SIDESLIP ANGLE	DEGREES
183	CLIMB ANGLE	DEGREES
184	STAB NO. 2 ANGLE OF INCIDENCE	DEGREES
185	STAB NO. 2 FLAP ANGLE	DEGREES
186	STAB NO. 2 LIFT COEFFICIENT	
187	STAB NO. 2 DRAG COEFFICIENT	
188	STAB NO. 2 PITCHING MOMENT COEF	
189	STAB NO. 2 ANGLE OF ATTACK	DEGREES
190	STAB NO. 2 SIDESLIP ANGLE	DEGREES
191	HEADING ANGLE	DEGREES
192	ANGLE OF ATTACK	DEGREES
193	STAB NO. 3 ANGLE OF INCIDENCE	DEGREES
194	STAB NO. 3 FLAP ANGLE	DEGREES
195	STAB NO. 3 LIFT COEFFICIENT	
196	STAB NO. 3 DRAG COEFFICIENT	
197	STAB NO. 3 PITCHING MOMENT COEF	
198	STAB NO. 3 ANGLE OF ATTACK	DEGREES
199	STAB NO. 3 SIDESLIP ANGLE	DEGREES
200	ANGLE OF SIDESLIP	DEGREES
201	STAB NO. 4 ANGLE OF INCIDENCE	DEGREES
202	STAB NO. 4 FLAP ANGLE	DEGREES
203	STAB NO. 4 LIFT COEFFICIENT	
204	STAB NO. 4 DRAG COEFFICIENT	
205	STAB NO. 4 PITCHING MOMENT COEF	
206	STAB NO. 4 ANGLE OF ATTACK	DEGREES
207	STAB NO. 4 SIDESLIP ANGLE	DEGREES
208	ANGLE OF AERO YAW	DEGREES
209	VERTICAL ACC	G
210	RIGHT WING ANGLE OF INCIDENCE	DEGREES
211	RIGHT WING FLAP ANGLE	DEGREES
212	RIGHT WING LIFT COEFFICIENT	
213	RIGHT WING DRAG COEFFICIENT	
214	RIGHT WING PITCHING MOMENT COEF	
215	RIGHT WING ANGLE OF ATTACK	DEGREES
216	RIGHT WING SIDESLIP ANGLE	DEGREES
217	FORWARD ACC	G
218	LEFT WING ANGLE OF INCIDENCE	DEGREES
219	LEFT WING FLAP ANGLE	DEGREES
220	LEFT WING LIFT COEFFICIENT	
221	LEFT WING DRAG COEFFICIENT	
222	LEFT WING PITCHING MOMENT COEF	
223	LEFT WING ANGLE OF ATTACK	DEGREES
224	LEFT WING SIDESLIP ANGLE	DEGREES
225	LATERAL ACC	G
226	YAW VELOCITY, FIXED/BODY	DEG/SEC
227	PITCH VELOCITY, FIXED/BODY	DEG/SEC
228	ROLL VELOCITY, FIXED/BODY	DEG/SEC
229	X-COMP VELOCITY, FIXED AXES	FT/SEC
230	Y-COMP VELOCITY, FIXED AXES	FT/SEC
231	Z-COMP VELOCITY, FIXED AXES	FT/SEC
232	TOTAL DISTANCE FLOWN	FEET
233	YAW ANGLE, FIXED/BODY	DEGREES
234	PITCH ANGLE, FIXED/BODY	DEGREES
235	ROLL ANGLE, FIXED/BODY	DEGREES
236	X-COMP DISP., FIXED AXES	FEET
237	Y-COMP DISP., FIXED AXES	FEET
238	Z-COMP DISP., FIXED AXES	FEET
239	ALTITUDE	FEET
240	NOT USED	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
241	NOT USED	
242	NOT USED	
243	NOT USED	
244	COLLECTIVE STICK POSITION	PERCENTS
245	ROTOR 1, COLL FROM COLL STICK	DEGREES
246	ROTOR 1, F/A FROM COLL STICK	DEGREES
247	ROTOR 1, LAT FROM COLL STICK	DEGREES
248	ROTOR 2, COLL FROM COLL STICK	DEGREES
249	ROTOR 2, F/A FROM COLL STICK	DEGREES
250	ROTOR 2, LAT FROM COLL STICK	DEGREES
251	ROTOR 1, HUB SPRING F/A MOMENT	FT-LB
252	ROTOR 2, HUB SPRING F/A MOMENT	FT-LB
253	F/A CYCLIC STICK POSITION	PERCENTS
254	ROTOR 1, COLL FROM F/A STICK	DEGREES
255	ROTOR 1, F/A FROM F/A STICK	DEGREES
256	ROTOR 1, LAT FROM F/A STICK	DEGREES
257	ROTOR 2, COLL FROM F/A STICK	DEGREES
258	ROTOR 2, F/A FROM F/A STICK	DEGREES
259	ROTOR 2, LAT FROM F/A STICK	DEGREES
260	ROTOR 1, HUB SPRING LAT MOMENT	FT-LB
261	ROTOR 2, HUB SPRING LAT MOMENT	FT-LB
262	LATERAL CYCLIC STICK POSITION	PERCENTS
263	ROTOR 1, COLL FROM LAT STICK	DEGREES
264	ROTOR 1, F/A FROM LAT STICK	DEGREES
265	ROTOR 1, LAT FROM LAT STICK	DEGREES
266	ROTOR 2, COLL FROM LAT STICK	DEGREES
267	ROTOR 2, F/A FROM LAT STICK	DEGREES
268	ROTOR 2, LAT FROM LAT STICK	DEGREES
269	ROTOR 1, F/A PYLON DISPLACEMENT	DEGREES
270	ROTOR 2, F/A PYLON DISPLACEMENT	DEGREES
271	PEDAL POSITION	PERCENTS
272	ROTOR 1, COLL FROM PEDAL	
273	ROTOR 1, F/A FROM PEDAL	
274	ROTOR 1, LAT FROM PEDAL	
275	ROTOR 2, COLL FROM PEDAL	
276	ROTOR 2, F/A FROM PEDAL	
277	ROTOR 2, LAT FROM PEDAL	
278	ROTOR 1, LATERAL PYLON DISPLACEMENT	DEGREES
279	ROTOR 2, LATERAL PYLON DISPLACEMENT	DEGREES
280	ROTOR 1, COLL FROM SCAS + PYLON	DEGREES
281	ROTOR 1, F/A FROM SCAS + PYLON	DEGREES
282	ROTOR 1, LAT FROM SCAS + PYLON	DEGREES
283	ROTOR 2, COLL FROM SCAS + PYLON	DEGREES
284	ROTOR 2, F/A FROM SCAS + PYLON	DEGREES
285	ROTOR 2, LAT FROM SCAS + PYLON	DEGREES
286	ROTOR 1, F/A MAST ANGLE	DEGREES
287	ROTOR 2, F/A MAST ANGLE	DEGREES
288	ROTOR 1, TOTAL COLLECTIVE	DEGREES
289	ROTOR 1, TOTAL F/A CYCLIC	DEGREES
290	ROTOR 1, TOTAL LATERAL CYCLIC	DEGREES
291	ROTOR 2, TOTAL COLLECTIVE	DEGREES
292	ROTOR 2, TOTAL F/A CYCLIC	DEGREES
293	ROTOR 2, TOTAL LATERAL CYCLIC	DEGREES
294	ROTOR 1, LAT MAST ANGLE	DEGREES
295	ROTOR 2, LAT MAST ANGLE	DEGREES
296	ROTOR 1, BLADE MEAN FEATHERING	DEGREES
297	ROTOR 1, BLADE FEATHER AT PSI=0	DEGREES
298	ROTOR 1, BLADE FEATHER AT PSI=90	DEGREES
299	ROTOR 1, F/A FLAPPING, MAST/TPP	DEGREES
300	ROTOR 1, LATERAL FLAPPING, MAST/TPP	DEGREES

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
301	ROTOR 1, THRUST	POUNDS
302	ROTOR 1, H-FORCE	POUNDS
303	ROTOR 1, Y-FORCE	POUNDS
304	ROTOR 1, ADVANCE RATIO	
305	ROTOR 1, POWER COEFFICIENT	
306	ROTOR 1, THRUST COEFFICIENT	
307	ROTOR 1, INDUCED VELOCITY	FT/SEC
308	ROTOR 2, BLADE MEAN FEATHERING	DEGREES
309	ROTOR 2, BLADE FEATHER AT PSI=0	DEGREES
310	ROTOR 2, BLADE FEATHER AT PSI=90	DEGREES
311	ROTOR 2, F/A FLAPPING, MAST/TPP	DEGREES
312	ROTOR 2, LATERAL FLAPPING, MAST/TPP	DEGREES
313	ROTOR 2, THRUST	POUNDS
314	ROTOR 2, H-FORCE	POUNDS
315	ROTOR 2, Y-FORCE	POUNDS
316	ROTOR 2, ADVANCE RATIO	
317	ROTOR 2, POWER COEFFICIENT	
318	ROTOR 2, THRUST COEFFICIENT	
319	ROTOR 2, INDUCED VELOCITY	FT/SEC
320	ROTOR 1, AZIMUTH LOCATION, BLADE 1	DEGREES
321	ROTOR 1, FLAPPING,HUB/MAST,BLADE 1	DEGREES
322	ROTOR 1, FLAPPING LIMIT	DEGREES
323	ROTOR 1, U VELOCITY, MAST AXES	FT/SEC
324	ROTOR 1, V VELOCITY, MAST AXES	FT/SEC
325	ROTOR 1, W VELOCITY, MAST AXES	FT/SEC
326	ROTOR 1, X SHEAR FORCE	POUNDS
327	ROTOR 1, Y SHEAR FORCE	POUNDS
328	ROTOR 1, Z SHEAR FORCE	POUNDS
329	NOT USED	
330	NOT USED	
331	NOT USED	
332	NOT USED	
333	ROTOR 2, AZIMUTH LOCATION, BLADE 1	DEGREES
334	ROTOR 2, FLAPPING,HUB/MAST,BLADE 1	DEGREES
335	ROTOR 2, FLAPPING LIMIT	DEGREES
336	ROTOR 2, U VELOCITY, MAST AXES	FT/SEC
337	ROTOR 2, V VELOCITY, MAST AXES	FT/SEC
338	ROTOR 2, W VELOCITY, MAST AXES	FT/SEC
339	ROTOR 2, X SHEAR FORCE	POUNDS
340	ROTOR 2, Y SHEAR FORCE	POUNDS
341	ROTOR 2, Z SHEAR FORCE	POUNDS
342	NOT USED	
343	NOT USED	
344	NOT USED	
345	NOT USED	
346	AZIMUTH, ROTOR 1, BLADE 1	DEGREES
347	AZIMUTH, ROTOR 1, BLADE 2	DEGREES
348	AZIMUTH, ROTOR 1, BLADE 3	DEGREES
349	AZIMUTH, ROTOR 1, BLADE 4	DEGREES
350	AZIMUTH, ROTOR 1, BLADE 5	DEGREES
351	AZIMUTH, ROTOR 1, BLADE 6	DEGREES
352	AZIMUTH, ROTOR 1, BLADE 7	DEGREES
353	GEN.COORD.,ROTOR 1,MODE 1,BLADE 1	
354	GEN.COORD.,ROTOR 1,MODE 1,BLADE 2	
355	GEN.COORD.,ROTOR 1,MODE 1,BLADE 3	
356	GEN.COORD.,ROTOR 1,MODE 1,BLADE 4	
357	GEN.COORD.,ROTOR 1,MODE 1,BLADE 5	
358	GEN.COORD.,ROTOR 1,MODE 1,BLADE 6	
359	GEN.COORD.,ROTOR 1,MODE 1,BLADE 7	
360	GEN.COORD.,ROTOR 1,MODE 2,BLADE 1	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
361	GEN.COORD.,ROTOR 1,MODE 2,BLADE 2	
362	GEN.COORD.,ROTOR 1,MODE 2,BLADE 3	
363	GEN.COORD.,ROTOR 1,MODE 2,BLADE 4	
364	GEN.COORD.,ROTOR 1,MODE 2,BLADE 5	
365	GEN.COORD.,ROTOR 1,MODE 2,BLADE 6	
366	GEN.COORD.,ROTOR 1,MODE 2,BLADE 7	
367	GEN.COORD.,ROTOR 1,MODE 3,BLADE 1	
368	GEN.COORD.,ROTOR 1,MODE 3,BLADE 2	
369	GEN.COORD.,ROTOR 1,MODE 3,BLADE 3	
370	GEN.COORD.,ROTOR 1,MODE 3,BLADE 4	
371	GEN.COORD.,ROTOR 1,MODE 3,BLADE 5	
372	GEN.COORD.,ROTOR 1,MODE 3,BLADE 6	
373	GEN.COORD.,ROTOR 1,MODE 3,BLADE 7	
374	GEN.COORD.,ROTOR 1,MODE 4,BLADE 1	
375	GEN.COORD.,ROTOR 1,MODE 4,BLADE 2	
376	GEN.COORD.,ROTOR 1,MODE 4,BLADE 3	
377	GEN.COORD.,ROTOR 1,MODE 4,BLADE 4	
378	GEN.COORD.,ROTOR 1,MODE 4,BLADE 5	
379	GEN.COORD.,ROTOR 1,MODE 4,BLADE 6	
380	GEN.COORD.,ROTOR 1,MODE 4,BLADE 7	
381	GEN.COORD.,ROTOR 1,MODE 5,BLADE 1	
382	GEN.COORD.,ROTOR 1,MODE 5,BLADE 2	
383	GEN.COORD.,ROTOR 1,MODE 5,BLADE 3	
384	GEN.COORD.,ROTOR 1,MODE 5,BLADE 4	
385	GEN.COORD.,ROTOR 1,MODE 5,BLADE 5	
386	GEN.COORD.,ROTOR 1,MODE 5,BLADE 6	
387	GEN.COORD.,ROTOR 1,MODE 5,BLADE 7	
388	GEN.COORD.,ROTOR 1,MODE 6,BLADE 1	
389	GEN.COORD.,ROTOR 1,MODE 6,BLADE 2	
390	GEN.COORD.,ROTOR 1,MODE 6,BLADE 3	
391	GEN.COORD.,ROTOR 1,MODE 6,BLADE 4	
392	GEN.COORD.,ROTOR 1,MODE 6,BLADE 5	
393	GEN.COORD.,ROTOR 1,MODE 6,BLADE 6	
394	GEN.COORD.,ROTOR 1,MODE 6,BLADE 7	
395	GEN.COORD.,ROTOR 1,MODE 7,BLADE 1	
396	GEN.COORD.,ROTOR 1,MODE 7,BLADE 2	
397	GEN.COORD.,ROTOR 1,MODE 7,BLADE 3	
398	GEN.COORD.,ROTOR 1,MODE 7,BLADE 4	
399	GEN.COORD.,ROTOR 1,MODE 7,BLADE 5	
400	GEN.COORD.,ROTOR 1,MODE 7,BLADE 6	
401	GEN.COORD.,ROTOR 1,MODE 7,BLADE 7	
402	GEN.COORD.,ROTOR 1,MODE 8,BLADE 1	
403	GEN.COORD.,ROTOR 1,MODE 8,BLADE 2	
404	GEN.COORD.,ROTOR 1,MODE 8,BLADE 3	
405	GEN.COORD.,ROTOR 1,MODE 8,BLADE 4	
406	GEN.COORD.,ROTOR 1,MODE 8,BLADE 5	
407	GEN.COORD.,ROTOR 1,MODE 8,BLADE 6	
408	GEN.COORD.,ROTOR 1,MODE 8,BLADE 7	
409	GEN.COORD.,ROTOR 1,MODE 9,BLADE 1	
410	GEN.COORD.,ROTOR 1,MODE 9,BLADE 2	
411	GEN.COORD.,ROTOR 1,MODE 9,BLADE 3	
412	GEN.COORD.,ROTOR 1,MODE 9,BLADE 4	
413	GEN.COORD.,ROTOR 1,MODE 9,BLADE 5	
414	GEN.COORD.,ROTOR 1,MODE 9,BLADE 6	
415	GEN.COORD.,ROTOR 1,MODE 9,BLADE 7	
416	GEN.COORD.,ROTOR 1,MODE 10BLADE 1	
417	GEN.COORD.,ROTOR 1,MODE 10BLADE 2	
418	GEN.COORD.,ROTOR 1,MODE 10BLADE 3	
419	GEN.COORD.,ROTOR 1,MODE 10BLADE 4	
420	GEN.COORD.,ROTOR 1,MODE 10BLADE 5	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
421	GEN.COORD..ROTOR 1,MODE 10BLADE 6	
422	GEN.COORD..ROTOR 1,MODE 10BLADE 7	
423	GEN.COORD..ROTOR 1,MODE 11BLADE 1	
424	GEN.COORD..ROTOR 1,MODE 11BLADE 2	
425	GEN.COORD..ROTOR 1,MODE 11BLADE 3	
426	GEN.COORD..ROTOR 1,MODE 11BLADE 4	
427	GEN.COORD..ROTOR 1,MODE 11BLADE 5	
428	GEN.COORD..ROTOR 1,MODE 11BLADE 6	
429	GEN.COORD..ROTOR 1,MODE 11BLADE 7	
430	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 1	FEET
431	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 2	FEET
432	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 3	FEET
433	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 4	FEET
434	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 5	FEET
435	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 6	FEET
436	TIP DEFL.OUT-OF-PLANE,ROTOR 1,BLADE 7	FEET
437	TIP DEFL. INPLANE,ROTOR 1,BLADE 1	FEET
438	TIP DEFL. INPLANE,ROTOR 1,BLADE 2	FEET
439	TIP DEFL. INPLANE,ROTOR 1,BLADE 3	FEET
440	TIP DEFL. INPLANE,ROTOR 1,BLADE 4	FEET
441	TIP DEFL. INPLANE,ROTOR 1,BLADE 5	FEET
442	TIP DEFL. INPLANE,ROTOR 1,BLADE 6	FEET
443	TIP DEFL. INPLANE,ROTOR 1,BLADE 7	FEET
444	TIP TWIST DEFL..ROTOR 1,BLADE 1	DEGREES
445	TIP TWIST DEFL..ROTOR 1,BLADE 2	DEGREES
446	TIP TWIST DEFL..ROTOR 1,BLADE 3	DEGREES
447	TIP TWIST DEFL..ROTOR 1,BLADE 4	DEGREES
448	TIP TWIST DEFL..ROTOR 1,BLADE 5	DEGREES
449	TIP TWIST DEFL..ROTOR 1,BLADE 6	DEGREES
450	TIP TWIST DEFL..ROTOR 1,BLADE 7	DEGREES
451	VERTICAL HUB SHEAR,ROTOR 1,BLADE 1	POUNDS
452	VERTICAL HUB SHEAR,ROTOR 1,BLADE 2	POUNDS
453	VERTICAL HUB SHEAR,ROTOR 1,BLADE 3	POUNDS
454	VERTICAL HUB SHEAR,ROTOR 1,BLADE 4	POUNDS
455	VERTICAL HUB SHEAR,ROTOR 1,BLADE 5	POUNDS
456	VERTICAL HUB SHEAR,ROTOR 1,BLADE 6	POUNDS
457	VERTICAL HUB SHEAR,ROTOR 1,BLADE 7	POUNDS
458	INPLANE HUB SHEAR,ROTOR 1,BLADE 1	POUNDS
459	INPLANE HUB SHEAR,ROTOR 1,BLADE 2	POUNDS
460	INPLANE HUB SHEAR,ROTOR 1,BLADE 3	POUNDS
461	INPLANE HUB SHEAR,ROTOR 1,BLADE 4	POUNDS
462	INPLANE HUB SHEAR,ROTOR 1,BLADE 5	POUNDS
463	INPLANE HUB SHEAR,ROTOR 1,BLADE 6	POUNDS
464	INPLANE HUB SHEAR,ROTOR 1,BLADE 7	POUNDS
465	BEAM BEND.MOMENT,ROTOR 1,BLADE 1	IN-LB
466	BEAM BEND.MOMENT,ROTOR 1,BLADE 2	IN-LB
467	BEAM BEND.MOMENT,ROTOR 1,BLADE 3	IN-LB
468	BEAM BEND.MOMENT,ROTOR 1,BLADE 4	IN-LB
469	BEAM BEND.MOMENT,ROTOR 1,BLADE 5	IN-LB
470	BEAM BEND.MOMENT,ROTOR 1,BLADE 6	IN-LB
471	BEAM BEND.MOMENT,ROTOR 1,BLADE 7	IN-LB
472	CHORD BEND.MOMENT,ROTOR 1,BLADE 1	IN-LB
473	CHORD BEND.MOMENT,ROTOR 1,BLADE 2	IN-LB
474	CHORD BEND.MOMENT,ROTOR 1,BLADE 3	IN-LB
475	CHORD BEND.MOMENT,ROTOR 1,BLADE 4	IN-LB
476	CHORD BEND.MOMENT,ROTOR 1,BLADE 5	IN-LB
477	CHORD BEND.MOMENT,ROTOR 1,BLADE 6	IN-LB
478	CHORD BEND.MOMENT,ROTOR 1,BLADE 7	IN-LB
479	TORSIONAL MOMENT,ROTOR 1,BLADE 1	IN-LB
480	TORSIONAL MOMENT,ROTOR 1,BLADE 2	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
481	TORSIONAL MOMENT,ROTOR 1,BLADE 3	IN-LB
482	TORSIONAL MOMENT,ROTOR 1,BLADE 4	IN-LB
483	TORSIONAL MOMENT,ROTOR 1,BLADE 5	IN-LB
484	TORSIONAL MOMENT,ROTOR 1,BLADE 6	IN-LB
485	TORSIONAL MOMENT,ROTOR 1,BLADE 7	IN-LB
486	AZIMUTH, ROTOR 2, BLADE 1	DEGREES
487	AZIMUTH, ROTOR 2, BLADE 2	DEGREES
488	AZIMUTH, ROTOR 2, BLADE 3	DEGREES
489	AZIMUTH, ROTOR 2, BLADE 4	DEGREES
490	AZIMUTH, ROTOR 2, BLADE 5	DEGREES
491	AZIMUTH, ROTOR 2, BLADE 6	DEGREES
492	AZIMUTH, ROTOR 2, BLADE 7	DEGREES
493	GEN.COORD.,ROTOR 2,MODE 1,BLADE 1	
494	GEN.COORD.,ROTOR 2,MODE 1,BLADE 2	
495	GEN.COORD.,ROTOR 2,MODE 1,BLADE 3	
496	GEN.COORD.,ROTOR 2,MODE 1,BLADE 4	
497	GEN.COORD.,ROTOR 2,MODE 1,BLADE 5	
498	GEN.COORD.,ROTOR 2,MODE 1,BLADE 6	
499	GEN.COORD.,ROTOR 2,MODE 1,BLADE 7	
500	GEN.COORD.,ROTOR 2,MODE 2,BLADE 1	
501	GEN.COORD.,ROTOR 2,MODE 2,BLADE 2	
502	GEN.COORD.,ROTOR 2,MODE 2,BLADE 3	
503	GEN.COORD.,ROTOR 2,MODE 2,BLADE 4	
504	GEN.COORD.,ROTOR 2,MODE 2,BLADE 5	
505	GEN.COORD.,ROTOR 2,MODE 2,BLADE 6	
506	GEN.COORD.,ROTOR 2,MODE 2,BLADE 7	
507	GEN.COORD.,ROTOR 2,MODE 3,BLADE 1	
508	GEN.COORD.,ROTOR 2,MODE 3,BLADE 2	
509	GEN.COORD.,ROTOR 2,MODE 3,BLADE 3	
510	GEN.COORD.,ROTOR 2,MODE 3,BLADE 4	
511	GEN.COORD.,ROTOR 2,MODE 3,BLADE 5	
512	GEN.COORD.,ROTOR 2,MODE 3,BLADE 6	
513	GEN.COORD.,ROTOR 2,MODE 3,BLADE 7	
514	GEN.COORD.,ROTOR 2,MODE 4,BLADE 1	
515	GEN.COORD.,ROTOR 2,MODE 4,BLADE 2	
516	GEN.COORD.,ROTOR 2,MODE 4,BLADE 3	
517	GEN.COORD.,ROTOR 2,MODE 4,BLADE 4	
518	GEN.COORD.,ROTOR 2,MODE 4,BLADE 5	
519	GEN.COORD.,ROTOR 2,MODE 4,BLADE 6	
520	GEN.COORD.,ROTOR 2,MODE 4,BLADE 7	
521	GEN.COORD.,ROTOR 2,MODE 5,BLADE 1	
522	GEN.COORD.,ROTOR 2,MODE 5,BLADE 2	
523	GEN.COORD.,ROTOR 2,MODE 5,BLADE 3	
524	GEN.COORD.,ROTOR 2,MODE 5,BLADE 4	
525	GEN.COORD.,ROTOR 2,MODE 5,BLADE 5	
526	GEN.COORD.,ROTOR 2,MODE 5,BLADE 6	
527	GEN.COORD.,ROTOR 2,MODE 5,BLADE 7	
528	GEN.COORD.,ROTOR 2,MODE 6,BLADE 1	
529	GEN.COORD.,ROTOR 2,MODE 6,BLADE 2	
530	GEN.COORD.,ROTOR 2,MODE 6,BLADE 3	
531	GEN.COORD.,ROTOR 2,MODE 6,BLADE 4	
532	GEN.COORD.,ROTOR 2,MODE 6,BLADE 5	
533	GEN.COORD.,ROTOR 2,MODE 6,BLADE 6	
534	GEN.COORD.,ROTOR 2,MODE 6,BLADE 7	
535	GEN.COORD.,ROTOR 2,MODE 7,BLADE 1	
536	GEN.COORD.,ROTOR 2,MODE 7,BLADE 2	
537	GEN.COORD.,ROTOR 2,MODE 7,BLADE 3	
538	GEN.COORD.,ROTOR 2,MODE 7,BLADE 4	
539	GEN.COORD.,ROTOR 2,MODE 7,BLADE 5	
540	GEN.COORD.,ROTOR 2,MODE 7,BLADE 6	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
541	GEN.COORD..ROTOR 2.MODE 7.BLADE 7	
542	GEN.COORD..ROTOR 2.MODE 8.BLADE 1	
543	GEN.COORD..ROTOR 2.MODE 8.BLADE 2	
544	GEN.COORD..ROTOR 2.MODE 8.BLADE 3	
545	GEN.COORD..ROTOR 2.MODE 8.BLADE 4	
546	GEN.COORD..ROTOR 2.MODE 8.BLADE 5	
547	GEN.COORD..ROTOR 2.MODE 8.BLADE 6	
548	GEN.COORD..ROTOR 2.MODE 8.BLADE 7	
549	GEN.COORD..ROTOR 2.MODE 9.BLADE 1	
550	GEN.COORD..ROTOR 2.MODE 9.BLADE 2	
551	GEN.COORD..ROTOR 2.MODE 9.BLADE 3	
552	GEN.COORD..ROTOR 2.MODE 9.BLADE 4	
553	GEN.COORD..ROTOR 2.MODE 9.BLADE 5	
554	GEN.COORD..ROTOR 2.MODE 9.BLADE 6	
555	GEN.COORD..ROTOR 2.MODE 9.BLADE 7	
556	GEN.COORD..ROTOR 2.MODE 10BLADE 1	
557	GEN.COORD..ROTOR 2.MODE 10BLADE 2	
558	GEN.COORD..ROTOR 2.MODE 10BLADE 3	
559	GEN.COORD..ROTOR 2.MODE 10BLADE 4	
560	GEN.COORD..ROTOR 2.MODE 10BLADE 5	
561	GEN.COORD..ROTOR 2.MODE 10BLADE 6	
562	GEN.COORD..ROTOR 2.MODE 10BLADE 7	
563	GEN.COORD..ROTOR 2.MODE 11BLADE 1	
564	GEN.COORD..ROTOR 2.MODE 11BLADE 2	
565	GEN.COORD..ROTOR 2.MODE 11BLADE 3	
566	GEN.COORD..ROTOR 2.MODE 11BLADE 4	
567	GEN.COORD..ROTOR 2.MODE 11BLADE 5	
568	GEN.COORD..ROTOR 2.MODE 11BLADE 6	
569	GEN.COORD..ROTOR 2.MODE 11BLADE 7	
570	TIP DEFL.OUT-OF-PLANE.ROTOR 2.BLADE 1	FEET
571	TIP DEFL.OUT-OF-PLANE.ROTOR 2.BLADE 2	FEET
572	TIP DEFL.OUT-OF-PLANE.ROTOR 2.BLADE 3	FEET
573	TIP DEFL.OUT-OF-PLANE.ROTOR 2.BLADE 4	FEET
574	TIP DEFL.OUT-OF-PLANE.ROTOR 2.BLADE 5	FEET
575	TIP DEFL.OUT-OF-PLANE.ROTOR 2.BLADE 6	FEET
576	TIP DEFL.OUT-OF-PLANE.ROTOR 2.BLADE 7	FEET
577	TIP DEFL. INPLANE.ROTOR 2.BLADE 1	FEET
578	TIP DEFL. INPLANE.ROTOR 2.BLADE 2	FEET
579	TIP DEFL. INPLANE.ROTOR 2.BLADE 3	FEET
580	TIP DEFL. INPLANE.ROTOR 2.BLADE 4	FEET
581	TIP DEFL. INPLANE.ROTOR 2.BLADE 5	FEET
582	TIP DEFL. INPLANE.ROTOR 2.BLADE 6	FEET
583	TIP DEFL. INPLANE.ROTOR 2.BLADE 7	FEET
584	TIP TWIST DEFL..ROTOR 2.BLADE 1	DEGREES
585	TIP TWIST DEFL..ROTOR 2.BLADE 2	DEGREES
586	TIP TWIST DEFL..ROTOR 2.BLADE 3	DEGREES
587	TIP TWIST DEFL..ROTOR 2.BLADE 4	DEGREES
588	TIP TWIST DEFL..ROTOR 2.BLADE 5	DEGREES
589	TIP TWIST DEFL..ROTOR 2.BLADE 6	DEGREES
590	TIP TWIST DEFL..ROTOR 2.BLADE 7	DEGREES
591	VERTICAL HUB SHEAR.ROTOR 2.BLADE 1	POUNDS
592	VERTICAL HUB SHEAR.ROTOR 2.BLADE 2	POUNDS
593	VERTICAL HUB SHEAR.ROTOR 2.BLADE 3	POUNDS
594	VERTICAL HUB SHEAR.ROTOR 2.BLADE 4	POUNDS
595	VERTICAL HUB SHEAR.ROTOR 2.BLADE 5	POUNDS
596	VERTICAL HUB SHEAR.ROTOR 2.BLADE 6	POUNDS
597	VERTICAL HUB SHEAR.ROTOR 2.BLADE 7	POUNDS
598	INPLANE HUB SHEAR.ROTOR 2.BLADE 1	POUNDS
599	INPLANE HUB SHEAR.ROTOR 2.BLADE 2	POUNDS
600	INPLANE HUB SHEAR.ROTOR 2.BLADE 3	POUNDS

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
601	INPLANE HUB SHEAR,ROTOR 2,BLADE 4	POUNDS
602	INPLANE HUB SHEAR,ROTOR 2,BLADE 5	POUNDS
603	INPLANE HUB SHEAR,ROTOR 2,BLADE 6	POUNDS
604	INPLANE HUB SHEAR,ROTOR 2,BLADE 7	POUNDS
605	BEAM BEND.MOMENT,ROTOR 2,BLADE 1	IN-LB
606	BEAM BEND.MOMENT,ROTOR 2,BLADE 2	IN-LB
607	BEAM BEND.MOMENT,ROTOR 2,BLADE 3	IN-LB
608	BEAM BEND.MOMENT,ROTOR 2,BLADE 4	IN-LB
609	BEAM BEND.MOMENT,ROTOR 2,BLADE 5	IN-LB
610	BEAM BEND.MOMENT,ROTOR 2,BLADE 6	IN-LB
611	BEAM BEND.MOMENT,ROTOR 2,BLADE 7	IN-LB
612	CHORD BEND.MOMENT,ROTOR 2,BLADE 1	IN-LB
613	CHORD BEND.MOMENT,ROTOR 2,BLADE 2	IN-LB
614	CHORD BEND.MOMENT,ROTOR 2,BLADE 3	IN-LB
615	CHORD BEND.MOMENT,ROTOR 2,BLADE 4	IN-LB
616	CHORD BEND.MOMENT,ROTOR 2,BLADE 5	IN-LB
617	CHORD BEND.MOMENT,ROTOR 2,BLADE 6	IN-LB
618	CHORD BEND.MOMENT,ROTOR 2,BLADE 7	IN-LB
619	TORSIONAL MOMENT,ROTOR 2,BLADE 1	IN-LB
620	TORSIONAL MOMENT,ROTOR 2,BLADE 2	IN-LB
621	TORSIONAL MOMENT,ROTOR 2,BLADE 3	IN-LB
622	TORSIONAL MOMENT,ROTOR 2,BLADE 4	IN-LB
623	TORSIONAL MOMENT,ROTOR 2,BLADE 5	IN-LB
624	TORSIONAL MOMENT,ROTOR 2,BLADE 6	IN-LB
625	TORSIONAL MOMENT,ROTOR 2,BLADE 7	IN-LB
626	RTR 1,BLD 1,STA 20, BEAM BEND MOM	IN-LB
627	RTR 1,BLD 2,STA 20, BEAM BEND MOM	IN-LB
628	RTR 1,BLD 3,STA 20, BEAM BEND MOM	IN-LB
629	RTR 1,BLD 4,STA 20, BEAM BEND MOM	IN-LB
630	RTR 1,BLD 5,STA 20, BEAM BEND MOM	IN-LB
631	RTR 1,BLD 6,STA 20, BEAM BEND MOM	IN-LB
632	RTR 1,BLD 7,STA 20, BEAM BEND MOM	IN-LB
633	RTR 1,BLD 1,STA 19, BEAM BEND MOM	IN-LB
634	RTR 1,BLD 2,STA 19, BEAM BEND MOM	IN-LB
635	RTR 1,BLD 3,STA 19, BEAM BEND MOM	IN-LB
636	RTR 1,BLD 4,STA 19, BEAM BEND MOM	IN-LB
637	RTR 1,BLD 5,STA 19, BEAM BEND MOM	IN-LB
638	RTR 1,BLD 6,STA 19, BEAM BEND MOM	IN-LB
639	RTR 1,BLD 7,STA 19, BEAM BEND MOM	IN-LB
640	RTR 1,BLD 1,STA 18, BEAM BEND MOM	IN-LB
641	RTR 1,BLD 2,STA 18, BEAM BEND MOM	IN-LB
642	RTR 1,BLD 3,STA 18, BEAM BEND MOM	IN-LB
643	RTR 1,BLD 4,STA 18, BEAM BEND MOM	IN-LB
644	RTR 1,BLD 5,STA 18, BEAM BEND MOM	IN-LB
645	RTR 1,BLD 6,STA 18, BEAM BEND MOM	IN-LB
646	RTR 1,BLD 7,STA 18, BEAM BEND MOM	IN-LB
647	RTR 1,BLD 1,STA 17, BEAM BEND MOM	IN-LB
648	RTR 1,BLD 2,STA 17, BEAM BEND MOM	IN-LB
649	RTR 1,BLD 3,STA 17, BEAM BEND MOM	IN-LB
650	RTR 1,BLD 4,STA 17, BEAM BEND MOM	IN-LB
651	RTR 1,BLD 5,STA 17, BEAM BEND MOM	IN-LB
652	RTR 1,BLD 6,STA 17, BEAM BEND MOM	IN-LB
653	RTR 1,BLD 7,STA 17, BEAM BEND MOM	IN-LB
654	RTR 1,BLD 1,STA 16, BEAM BEND MOM	IN-LB
655	RTR 1,BLD 2,STA 16, BEAM BEND MOM	IN-LB
656	RTR 1,BLD 3,STA 16, BEAM BEND MOM	IN-LB
657	RTR 1,BLD 4,STA 16, BEAM BEND MOM	IN-LB
658	RTR 1,BLD 5,STA 16, BEAM BEND MOM	IN-LB
659	RTR 1,BLD 6,STA 16, BEAM BEND MOM	IN-LB
660	RTR 1,BLD 7,STA 16, BEAM BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
661	RTR 1,BLD 1,STA 15, BEAM BEND MOM	IN-LB
662	RTR 1,BLD 2,STA 15, BEAM BEND MOM	IN-LB
663	RTR 1,BLD 3,STA 15, BEAM BEND MOM	IN-LB
664	RTR 1,BLD 4,STA 15, BEAM BEND MOM	IN-LB
665	RTR 1,BLD 5,STA 15, BEAM BEND MOM	IN-LB
666	RTR 1,BLD 6,STA 15, BEAM BEND MOM	IN-LB
667	RTR 1,BLD 7,STA 15, BEAM BEND MOM	IN-LB
668	RTR 1,BLD 1,STA 14, BEAM BEND MOM	IN-LB
669	RTR 1,BLD 2,STA 14, BEAM BEND MOM	IN-LB
670	RTR 1,BLD 3,STA 14, BEAM BEND MOM	IN-LB
671	RTR 1,BLD 4,STA 14, BEAM BEND MOM	IN-LB
672	RTR 1,BLD 5,STA 14, BEAM BEND MOM	IN-LB
673	RTR 1,BLD 6,STA 14, BEAM BEND MOM	IN-LB
674	RTR 1,BLD 7,STA 14, BEAM BEND MOM	IN-LB
675	RTR 1,BLD 1,STA 13, BEAM BEND MOM	IN-LB
676	RTR 1,BLD 2,STA 13, BEAM BEND MOM	IN-LB
677	RTR 1,BLD 3,STA 13, BEAM BEND MOM	IN-LB
678	RTR 1,BLD 4,STA 13, BEAM BEND MOM	IN-LB
679	RTR 1,BLD 5,STA 13, BEAM BEND MOM	IN-LB
680	RTR 1,BLD 6,STA 13, BEAM BEND MOM	IN-LB
681	RTR 1,BLD 7,STA 13, BEAM BEND MOM	IN-LB
682	RTR 1,BLD 1,STA 12, BEAM BEND MOM	IN-LB
683	RTR 1,BLD 2,STA 12, BEAM BEND MOM	IN-LB
684	RTR 1,BLD 3,STA 12, BEAM BEND MOM	IN-LB
685	RTR 1,BLD 4,STA 12, BEAM BEND MOM	IN-LB
686	RTR 1,BLD 5,STA 12, BEAM BEND MOM	IN-LB
687	RTR 1,BLD 6,STA 12, BEAM BEND MOM	IN-LB
688	RTR 1,BLD 7,STA 12, BEAM BEND MOM	IN-LB
689	RTR 1,BLD 1,STA 11, BEAM BEND MOM	IN-LB
690	RTR 1,BLD 2,STA 11, BEAM BEND MOM	IN-LB
691	RTR 1,BLD 3,STA 11, BEAM BEND MOM	IN-LB
692	RTR 1,BLD 4,STA 11, BEAM BEND MOM	IN-LB
693	RTR 1,BLD 5,STA 11, BEAM BEND MOM	IN-LB
694	RTR 1,BLD 6,STA 11, BEAM BEND MOM	IN-LB
695	RTR 1,BLD 7,STA 11, BEAM BEND MOM	IN-LB
696	RTR 1,BLD 1,STA 10, BEAM BEND MOM	IN-LB
697	RTR 1,BLD 2,STA 10, BEAM BEND MOM	IN-LB
698	RTR 1,BLD 3,STA 10, BEAM BEND MOM	IN-LB
699	RTR 1,BLD 4,STA 10, BEAM BEND MOM	IN-LB
700	RTR 1,BLD 5,STA 10, BEAM BEND MOM	IN-LB
701	RTR 1,BLD 6,STA 10, BEAM BEND MOM	IN-LB
702	RTR 1,BLD 7,STA 10, BEAM BEND MOM	IN-LB
703	RTR 1,BLD 1,STA 9, BEAM BEND MOM	IN-LB
704	RTR 1,BLD 2,STA 9, BEAM BEND MOM	IN-LB
705	RTR 1,BLD 3,STA 9, BEAM BEND MOM	IN-LB
706	RTR 1,BLD 4,STA 9, BEAM BEND MOM	IN-LB
707	RTR 1,BLD 5,STA 9, BEAM BEND MOM	IN-LB
708	RTR 1,BLD 6,STA 9, BEAM BEND MOM	IN-LB
709	RTR 1,BLD 7,STA 9, BEAM BEND MOM	IN-LB
710	RTR 1,BLD 1,STA 8, BEAM BEND MOM	IN-LB
711	RTR 1,BLD 2,STA 8, BEAM BEND MOM	IN-LB
712	RTR 1,BLD 3,STA 8, BEAM BEND MOM	IN-LB
713	RTR 1,BLD 4,STA 8, BEAM BEND MOM	IN-LB
714	RTR 1,BLD 5,STA 8, BEAM BEND MOM	IN-LB
715	RTR 1,BLD 6,STA 8, BEAM BEND MOM	IN-LB
716	RTR 1,BLD 7,STA 8, BEAM BEND MOM	IN-LB
717	RTR 1,BLD 1,STA 7, BEAM BEND MOM	IN-LB
718	RTR 1,BLD 2,STA 7, BEAM BEND MOM	IN-LB
719	RTR 1,BLD 3,STA 7, BEAM BEND MOM	IN-LB
720	RTR 1,BLD 4,STA 7, BEAM BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
721	RTR 1,BLD 5,STA 7. BEAM BEND MOM	IN-LB
722	RTR 1,BLD 6,STA 7. BEAM BEND MOM	IN-LB
723	RTR 1,BLD 7,STA 7. BEAM BEND MOM	IN-LB
724	RTR 1,BLD 1,STA 6. BEAM BEND MOM	IN-LB
725	RTR 1,BLD 2,STA 6. BEAM BEND MOM	IN-LB
726	RTR 1,BLD 3,STA 6. BEAM BEND MOM	IN-LB
727	RTR 1,BLD 4,STA 6. BEAM BEND MOM	IN-LB
728	RTR 1,BLD 5,STA 6. BEAM BEND MOM	IN-LB
729	RTR 1,BLD 6,STA 6. BEAM BEND MOM	IN-LB
730	RTR 1,BLD 7,STA 6. BEAM BEND MOM	IN-LB
731	RTR 1,BLD 1,STA 5. BEAM BEND MOM	IN-LB
732	RTR 1,BLD 2,STA 5. BEAM BEND MOM	IN-LB
733	RTR 1,BLD 3,STA 5. BEAM BEND MOM	IN-LB
734	RTR 1,BLD 4,STA 5. BEAM BEND MOM	IN-LB
735	RTR 1,BLD 5,STA 5. BEAM BEND MOM	IN-LB
736	RTR 1,BLD 6,STA 5. BEAM BEND MOM	IN-LB
737	RTR 1,BLD 7,STA 5. BEAM BEND MOM	IN-LB
738	RTR 1,BLD 1,STA 4 BEAM BEND MOM	IN-LB
739	RTR 1,BLD 2,STA 4 BEAM BEND MOM	IN-LB
740	RTR 1,BLD 3,STA 4 BEAM BEND MOM	IN-LB
741	RTR 1,BLD 4,STA 4 BEAM BEND MOM	IN-LB
742	RTR 1,BLD 5,STA 4 BEAM BEND MOM	IN-LB
743	RTR 1,BLD 6,STA 4 BEAM BEND MOM	IN-LB
744	RTR 1,BLD 7,STA 4 BEAM BEND MOM	IN-LB
745	RTR 1,BLD 1,STA 3 BEAM BEND MOM	IN-LB
746	RTR 1,BLD 2,STA 3 BEAM BEND MOM	IN-LB
747	RTR 1,BLD 3,STA 3 BEAM BEND MOM	IN-LB
748	RTR 1,BLD 4,STA 3 BEAM BEND MOM	IN-LB
749	RTR 1,BLD 5,STA 3 BEAM BEND MOM	IN-LB
750	RTR 1,BLD 6,STA 3 BEAM BEND MOM	IN-LB
751	RTR 1,BLD 7,STA 3 BEAM BEND MOM	IN-LB
752	RTR 1,BLD 1,STA 2 BEAM BEND MOM	IN-LB
753	RTR 1,BLD 2,STA 2 BEAM BEND MOM	IN-LB
754	RTR 1,BLD 3,STA 2 BEAM BEND MOM	IN-LB
755	RTR 1,BLD 4,STA 2 BEAM BEND MOM	IN-LB
756	RTR 1,BLD 5,STA 2 BEAM BEND MOM	IN-LB
757	RTR 1,BLD 6,STA 2 BEAM BEND MOM	IN-LB
758	RTR 1,BLD 7,STA 2 BEAM BEND MOM	IN-LB
759	RTR 1,BLD 1,STA 1 BEAM BEND MOM	IN-LB
760	RTR 1,BLD 2,STA 1 BEAM BEND MOM	IN-LB
761	RTR 1,BLD 3,STA 1 BEAM BEND MOM	IN-LB
762	RTR 1,BLD 4,STA 1 BEAM BEND MOM	IN-LB
763	RTR 1,BLD 5,STA 1 BEAM BEND MOM	IN-LB
764	RTR 1,BLD 6,STA 1 BEAM BEND MOM	IN-LB
765	RTR 1,BLD 7,STA 1 BEAM BEND MOM	IN-LB
766	RTR 1,BLD 1,STA 0. BEAM BEND MOM	IN-LB
767	RTR 1,BLD 2,STA 0. BEAM BEND MOM	IN-LB
768	RTR 1,BLD 3,STA 0. BEAM BEND MOM	IN-LB
769	RTR 1,BLD 4,STA 0. BEAM BEND MOM	IN-LB
770	RTR 1,BLD 5,STA 0. BEAM BEND MOM	IN-LB
771	RTR 1,BLD 6,STA 0. BEAM BEND MOM	IN-LB
772	RTR 1,BLD 7,STA 0. BEAM BEND MOM	IN-LB
773	RTR 1,BLD 1,STA 20. CHRD BEND MOM	IN-LB
774	RTR 1,BLD 2,STA 20. CHRD BEND MOM	IN-LB
775	RTR 1,BLD 3,STA 20. CHRD BEND MOM	IN-LB
776	RTR 1,BLD 4,STA 20. CHRD BEND MOM	IN-LB
777	RTR 1,BLD 5,STA 20. CHRD BEND MOM	IN-LB
778	RTR 1,BLD 6,STA 20. CHRD BEND MOM	IN-LB
779	RTR 1,BLD 7,STA 20. CHRD BEND MOM	IN-LB
780	RTR 1,BLD 1,STA 19. CHRD BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
781	RTR 1,BLD 2,STA 19. CHRD BEND MOM	IN-LB
782	RTR 1,BLD 3,STA 19. CHRD BEND MOM	IN-LB
783	RTR 1,BLD 4,STA 19. CHRD BEND MOM	IN-LB
784	RTR 1,BLD 5,STA 19. CHRD BEND MOM	IN-LB
785	RTR 1,BLD 6,STA 19. CHRD BEND MOM	IN-LB
786	RTR 1,BLD 7,STA 19. CHRD BEND MOM	IN-LB
787	RTR 1,BLD 1,STA 18. CHRD BEND MOM	IN-LB
788	RTR 1,BLD 2,STA 18. CHRD BEND MOM	IN-LB
789	RTR 1,BLD 3,STA 18. CHRD BEND MOM	IN-LB
790	RTR 1,BLD 4,STA 18. CHRD BEND MOM	IN-LB
791	RTR 1,BLD 5,STA 18. CHRD BEND MOM	IN-LB
792	RTR 1,BLD 6,STA 18. CHRD BEND MOM	IN-LB
793	RTR 1,BLD 7,STA 18. CHRD BEND MOM	IN-LB
794	RTR 1,BLD 1,STA 17. CHRD BEND MOM	IN-LB
795	RTR 1,BLD 2,STA 17. CHRD BEND MOM	IN-LB
796	RTR 1,BLD 3,STA 17. CHRD BEND MOM	IN-LB
797	RTR 1,BLD 4,STA 17. CHRD BEND MOM	IN-LB
798	RTR 1,BLD 5,STA 17. CHRD BEND MOM	IN-LB
799	RTR 1,BLD 6,STA 17. CHRD BEND MOM	IN-LB
800	RTR 1,BLD 7,STA 17. CHRD BEND MOM	IN-LB
801	RTR 1,BLD 1,STA 16. CHRD BEND MOM	IN-LB
802	RTR 1,BLD 2,STA 16. CHRD BEND MOM	IN-LB
803	RTR 1,BLD 3,STA 16. CHRD BEND MOM	IN-LB
804	RTR 1,BLD 4,STA 16. CHRD BEND MOM	IN-LB
805	RTR 1,BLD 5,STA 16. CHRD BEND MOM	IN-LB
806	RTR 1,BLD 6,STA 16. CHRD BEND MOM	IN-LB
807	RTR 1,BLD 7,STA 16. CHRD BEND MOM	IN-LB
808	RTR 1,BLD 1,STA 15. CHRD BEND MOM	IN-LB
809	RTR 1,BLD 2,STA 15. CHRD BEND MOM	IN-LB
810	RTR 1,BLD 3,STA 15. CHRD BEND MOM	IN-LB
811	RTR 1,BLD 4,STA 15. CHRD BEND MOM	IN-LB
812	RTR 1,BLD 5,STA 15. CHRD BEND MOM	IN-LB
813	RTR 1,BLD 6,STA 15. CHRD BEND MOM	IN-LB
814	RTR 1,BLD 7,STA 15. CHRD BEND MOM	IN-LB
815	RTR 1,BLD 1,STA 14. CHRD BEND MOM	IN-LB
816	RTR 1,BLD 2,STA 14. CHRD BEND MOM	IN-LB
817	RTR 1,BLD 3,STA 14. CHRD BEND MOM	IN-LB
818	RTR 1,BLD 4,STA 14. CHRD BEND MOM	IN-LB
819	RTR 1,BLD 5,STA 14. CHRD BEND MOM	IN-LB
820	RTR 1,BLD 6,STA 14. CHRD BEND MOM	IN-LB
821	RTR 1,BLD 7,STA 14. CHRD BEND MOM	IN-LB
822	RTR 1,BLD 1,STA 13. CHRD BEND MOM	IN-LB
823	RTR 1,BLD 2,STA 13. CHRD BEND MOM	IN-LB
824	RTR 1,BLD 3,STA 13. CHRD BEND MOM	IN-LB
825	RTR 1,BLD 4,STA 13. CHRD BEND MOM	IN-LB
826	RTR 1,BLD 5,STA 13. CHRD BEND MOM	IN-LB
827	RTR 1,BLD 6,STA 13. CHRD BEND MOM	IN-LB
828	RTR 1,BLD 7,STA 13. CHRD BEND MOM	IN-LB
829	RTR 1,BLD 1,STA 12. CHRD BEND MOM	IN-LB
830	RTR 1,BLD 2,STA 12. CHRD BEND MOM	IN-LB
831	RTR 1,BLD 3,STA 12. CHRD BEND MOM	IN-LB
832	RTR 1,BLD 4,STA 12. CHRD BEND MOM	IN-LB
833	RTR 1,BLD 5,STA 12. CHRD BEND MOM	IN-LB
834	RTR 1,BLD 6,STA 12. CHRD BEND MOM	IN-LB
835	RTR 1,BLD 7,STA 12. CHRD BEND MOM	IN-LB
836	RTR 1,BLD 1,STA 11. CHRD BEND MOM	IN-LB
837	RTR 1,BLD 2,STA 11. CHRD BEND MOM	IN-LB
838	RTR 1,BLD 3,STA 11. CHRD BEND MOM	IN-LB
839	RTR 1,BLD 4,STA 11. CHRD BEND MOM	IN-LB
840	RTR 1,BLD 5,STA 11. CHRD BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
841	RTR 1.BLD 6.STA 11. CHRD BEND MOM	IN-LB
842	RTR 1.BLD 7.STA 11. CHRD BEND MOM	IN-LB
843	RTR 1.BLD 1.STA 10. CHRD BEND MOM	IN-LB
844	RTR 1.BLD 2.STA 10. CHRD BEND MOM	IN-LB
845	RTR 1.BLD 3.STA 10. CHRD BEND MOM	IN-LB
846	RTR 1.BLD 4.STA 10. CHRD BEND MOM	IN-LB
847	RTR 1.BLD 5.STA 10. CHRD BEND MOM	IN-LB
848	RTR 1.BLD 6.STA 10. CHRD BEND MOM	IN-LB
849	RTR 1.BLD 7.STA 10. CHRD BEND MOM	IN-LB
850	RTR 1.BLD 1.STA 9. CHRD BEND MOM	IN-LB
851	RTR 1.BLD 2.STA 9. CHRD BEND MOM	IN-LB
852	RTR 1.BLD 3.STA 9. CHRD BEND MOM	IN-LB
853	RTR 1.BLD 4.STA 9. CHRD BEND MOM	IN-LB
854	RTR 1.BLD 5.STA 9. CHRD BEND MOM	IN-LB
855	RTR 1.BLD 6.STA 9. CHRD BEND MOM	IN-LB
856	RTR 1.BLD 7.STA 9. CHRD BEND MOM	IN-LB
857	RTR 1.BLD 1.STA 8. CHRD BEND MOM	IN-LB
858	RTR 1.BLD 2.STA 8. CHRD BEND MOM	IN-LB
859	RTR 1.BLD 3.STA 8. CHRD BEND MOM	IN-LB
860	RTR 1.BLD 4.STA 8. CHRD BEND MOM	IN-LB
861	RTR 1.BLD 5.STA 8. CHRD BEND MOM	IN-LB
862	RTR 1.BLD 6.STA 8. CHRD BEND MOM	IN-LB
863	RTR 1.BLD 7.STA 8. CHRD BEND MOM	IN-LB
864	RTR 1.BLD 1.STA 7. CHRD BEND MOM	IN-LB
865	RTR 1.BLD 2.STA 7. CHRD BEND MOM	IN-LB
866	RTR 1.BLD 3.STA 7. CHRD BEND MOM	IN-LB
867	RTR 1.BLD 4.STA 7. CHRD BEND MOM	IN-LB
868	RTR 1.BLD 5.STA 7. CHRD BEND MOM	IN-LB
869	RTR 1.BLD 6.STA 7. CHRD BEND MOM	IN-LB
870	RTR 1.BLD 7.STA 7. CHRD BEND MOM	IN-LB
871	RTR 1.BLD 1.STA 6. CHRD BEND MOM	IN-LB
872	RTR 1.BLD 2.STA 6. CHRD BEND MOM	IN-LB
873	RTR 1.BLD 3.STA 6. CHRD BEND MOM	IN-LB
874	RTR 1.BLD 4.STA 6. CHRD BEND MOM	IN-LB
875	RTR 1.BLD 5.STA 6. CHRD BEND MOM	IN-LB
876	RTR 1.BLD 6.STA 6. CHRD BEND MOM	IN-LB
877	RTR 1.BLD 7.STA 6. CHRD BEND MOM	IN-LB
878	RTR 1.BLD 1.STA 5. CHRD BEND MOM	IN-LB
879	RTR 1.BLD 2.STA 5. CHRD BEND MOM	IN-LB
880	RTR 1.BLD 3.STA 5. CHRD BEND MOM	IN-LB
881	RTR 1.BLD 4.STA 5. CHRD BEND MOM	IN-LB
882	RTR 1.BLD 5.STA 5. CHRD BEND MOM	IN-LB
883	RTR 1.BLD 6.STA 5. CHRD BEND MOM	IN-LB
884	RTR 1.BLD 7.STA 5. CHRD BEND MOM	IN-LB
885	RTR 1.BLD 1.STA 4 CHRD BEND MOM	IN-LB
886	RTR 1.BLD 2.STA 4 CHRD BEND MOM	IN-LB
887	RTR 1.BLD 3.STA 4 CHRD BEND MOM	IN-LB
888	RTR 1.BLD 4.STA 4 CHRD BEND MOM	IN-LB
889	RTR 1.BLD 5.STA 4 CHRD BEND MOM	IN-LB
890	RTR 1.BLD 6.STA 4 CHRD BEND MOM	IN-LB
891	RTR 1.BLD 7.STA 4 CHRD BEND MOM	IN-LB
892	RTR 1.BLD 1.STA 3 CHRD BEND MOM	IN-LB
893	RTR 1.BLD 2.STA 3 CHRD BEND MOM	IN-LB
894	RTR 1.BLD 3.STA 3 CHRD BEND MOM	IN-LB
895	RTR 1.BLD 4.STA 3 CHRD BEND MOM	IN-LB
896	RTR 1.BLD 5.STA 3 CHRD BEND MOM	IN-LB
897	RTR 1.BLD 6.STA 3 CHRD BEND MOM	IN-LB
898	RTR 1.BLD 7.STA 3 CHRD BEND MOM	IN-LB
899	RTR 1.BLD 1.STA 2 CHRD BEND MOM	IN-LB
900	RTR 1.BLD 2.STA 2 CHRD BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
901	RTR 1,BLD 3,STA 2 CHRD BEND MOM	IN-LB
902	RTR 1,BLD 4,STA 2 CHRD BEND MOM	IN-LB
903	RTR 1,BLD 5,STA 2 CHRD BEND MOM	IN-LB
904	RTR 1,BLD 6,STA 2 CHRD BEND MOM	IN-LB
905	RTR 1,BLD 7,STA 2 CHRD BEND MOM	IN-LB
906	RTR 1,BLD 1,STA 1 CHRD BEND MOM	IN-LB
907	RTR 1,BLD 2,STA 1 CHRD BEND MOM	IN-LB
908	RTR 1,BLD 3,STA 1 CHRD BEND MOM	IN-LB
909	RTR 1,BLD 4,STA 1 CHRD BEND MOM	IN-LB
910	RTR 1,BLD 5,STA 1 CHRD BEND MOM	IN-LB
911	RTR 1,BLD 6,STA 1 CHRD BEND MOM	IN-LB
912	RTR 1,BLD 7,STA 1 CHRD BEND MOM	IN-LB
913	RTR 1,BLD 1,STA 0. CHRD BEND MOM	IN-LB
914	RTR 1,BLD 2,STA 0. CHRD BEND MOM	IN-LB
915	RTR 1,BLD 3,STA 0. CHRD BEND MOM	IN-LB
916	RTR 1,BLD 4,STA 0. CHRD BEND MOM	IN-LB
917	RTR 1,BLD 5,STA 0. CHRD BEND MOM	IN-LB
918	RTR 1,BLD 6,STA 0. CHRD BEND MOM	IN-LB
919	RTR 1,BLD 7,STA 0. CHRD BEND MOM	IN-LB
920	RTR 1,BLD 1,STA 20. TORS MOM	IN-LB
921	RTR 1,BLD 2,STA 20. TORS MOM	IN-LB
922	RTR 1,BLD 3,STA 20. TORS MOM	IN-LB
923	RTR 1,BLD 4,STA 20. TORS MOM	IN-LB
924	RTR 1,BLD 5,STA 20. TORS MOM	IN-LB
925	RTR 1,BLD 6,STA 20. TORS MOM	IN-LB
926	RTR 1,BLD 7,STA 20. TORS MOM	IN-LB
927	RTR 1,BLD 1,STA 19. TORS MOM	IN-LB
928	RTR 1,BLD 2,STA 19. TORS MOM	IN-LB
929	RTR 1,BLD 3,STA 19. TORS MOM	IN-LB
930	RTR 1,BLD 4,STA 19. TORS MOM	IN-LB
931	RTR 1,BLD 5,STA 19. TORS MOM	IN-LB
932	RTR 1,BLD 6,STA 19. TORS MOM	IN-LB
933	RTR 1,BLD 7,STA 19. TORS MOM	IN-LB
934	RTR 1,BLD 1,STA 18. TORS MOM	IN-LB
935	RTR 1,BLD 2,STA 18. TORS MOM	IN-LB
936	RTR 1,BLD 3,STA 18. TORS MOM	IN-LB
937	RTR 1,BLD 4,STA 18. TORS MOM	IN-LB
938	RTR 1,BLD 5,STA 18. TORS MOM	IN-LB
939	RTR 1,BLD 6,STA 18. TORS MOM	IN-LB
940	RTR 1,BLD 7,STA 18. TORS MOM	IN-LB
941	RTR 1,BLD 1,STA 17. TORS MOM	IN-LB
942	RTR 1,BLD 2,STA 17. TORS MOM	IN-LB
943	RTR 1,BLD 3,STA 17. TORS MOM	IN-LB
944	RTR 1,BLD 4,STA 17. TORS MOM	IN-LB
945	RTR 1,BLD 5,STA 17. TORS MOM	IN-LB
946	RTR 1,BLD 6,STA 17. TORS MOM	IN-LB
947	RTR 1,BLD 7,STA 17. TORS MOM	IN-LB
948	RTR 1,BLD 1,STA 16. TORS MOM	IN-LB
949	RTR 1,BLD 2,STA 16. TORS MOM	IN-LB
950	RTR 1,BLD 3,STA 16. TORS MOM	IN-LB
951	RTR 1,BLD 4,STA 16. TORS MOM	IN-LB
952	RTR 1,BLD 5,STA 16. TORS MOM	IN-LB
953	RTR 1,BLD 6,STA 16. TORS MOM	IN-LB
954	RTR 1,BLD 7,STA 16. TORS MOM	IN-LB
955	RTR 1,BLD 1,STA 15. TORS MOM	IN-LB
956	RTR 1,BLD 2,STA 15. TORS MOM	IN-LB
957	RTR 1,BLD 3,STA 15. TORS MOM	IN-LB
958	RTR 1,BLD 4,STA 15. TORS MOM	IN-LB
959	RTR 1,BLD 5,STA 15. TORS MOM	IN-LB
960	RTR 1,BLD 6,STA 15. TORS MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
961	RTR 1,BLD 7,STA 15, TORS MOM	IN-LB
962	RTR 1,BLD 1,STA 14, TORS MOM	IN-LB
963	RTR 1,BLD 2,STA 14, TORS MOM	IN-LB
964	RTR 1,BLD 3,STA 14, TORS MOM	IN-LB
965	RTR 1,BLD 4,STA 14, TORS MOM	IN-LB
966	RTR 1,BLD 5,STA 14, TORS MOM	IN-LB
967	RTR 1,BLD 6,STA 14, TORS MOM	IN-LB
968	RTR 1,BLD 7,STA 14, TORS MOM	IN-LB
969	RTR 1,BLD 1,STA 13, TORS MOM	IN-LB
970	RTR 1,BLD 2,STA 13, TORS MOM	IN-LB
971	RTR 1,BLD 3,STA 13, TORS MOM	IN-LB
972	RTR 1,BLD 4,STA 13, TORS MOM	IN-LB
973	RTR 1,BLD 5,STA 13, TORS MOM	IN-LB
974	RTR 1,BLD 6,STA 13, TORS MOM	IN-LB
975	RTR 1,BLD 7,STA 13, TORS MOM	IN-LB
976	RTR 1,BLD 1,STA 12, TORS MOM	IN-LB
977	RTR 1,BLD 2,STA 12, TORS MOM	IN-LB
978	RTR 1,BLD 3,STA 12, TORS MOM	IN-LB
979	RTR 1,BLD 4,STA 12, TORS MOM	IN-LB
980	RTR 1,BLD 5,STA 12, TORS MOM	IN-LB
981	RTR 1,BLD 6,STA 12, TORS MOM	IN-LB
982	RTR 1,BLD 7,STA 12, TORS MOM	IN-LB
983	RTR 1,BLD 1,STA 11, TORS MOM	IN-LB
984	RTR 1,BLD 2,STA 11, TORS MOM	IN-LB
985	RTR 1,BLD 3,STA 11, TORS MOM	IN-LB
986	RTR 1,BLD 4,STA 11, TORS MOM	IN-LB
987	RTR 1,BLD 5,STA 11, TORS MOM	IN-LB
988	RTR 1,BLD 6,STA 11, TORS MOM	IN-LB
989	RTR 1,BLD 7,STA 11, TORS MOM	IN-LB
990	RTR 1,BLD 1,STA 10, TORS MOM	IN-LB
991	RTR 1,BLD 2,STA 10, TORS MOM	IN-LB
992	RTR 1,BLD 3,STA 10, TORS MOM	IN-LB
993	RTR 1,BLD 4,STA 10, TORS MOM	IN-LB
994	RTR 1,BLD 5,STA 10, TORS MOM	IN-LB
995	RTR 1,BLD 6,STA 10, TORS MOM	IN-LB
996	RTR 1,BLD 7,STA 10, TORS MOM	IN-LB
997	RTR 1,BLD 1,STA 9, TORS MOM	IN-LB
998	RTR 1,BLD 2,STA 9, TORS MOM	IN-LB
999	RTR 1,BLD 3,STA 9, TORS MOM	IN-LB
1000	RTR 1,BLD 4,STA 9, TORS MOM	IN-LB
1001	RTR 1,BLD 5,STA 9, TORS MOM	IN-LB
1002	RTR 1,BLD 6,STA 9, TORS MOM	IN-LB
1003	RTR 1,BLD 7,STA 9, TORS MOM	IN-LB
1004	RTR 1,BLD 1,STA 8, TORS MOM	IN-LB
1005	RTR 1,BLD 2,STA 8, TORS MOM	IN-LB
1006	RTR 1,BLD 3,STA 8, TORS MOM	IN-LB
1007	RTR 1,BLD 4,STA 8, TORS MOM	IN-LB
1008	RTR 1,BLD 5,STA 8, TORS MOM	IN-LB
1009	RTR 1,BLD 6,STA 8, TORS MOM	IN-LB
1010	RTR 1,BLD 7,STA 8, TORS MOM	IN-LB
1011	RTR 1,BLD 1,STA 7, TORS MOM	IN-LB
1012	RTR 1,BLD 2,STA 7, TORS MOM	IN-LB
1013	RTR 1,BLD 3,STA 7, TORS MOM	IN-LB
1014	RTR 1,BLD 4,STA 7, TORS MOM	IN-LB
1015	RTR 1,BLD 5,STA 7, TORS MOM	IN-LB
1016	RTR 1,BLD 6,STA 7, TORS MOM	IN-LB
1017	RTR 1,BLD 7,STA 7, TORS MOM	IN-LB
1018	RTR 1,BLD 1,STA 6, TORS MOM	IN-LB
1019	RTR 1,BLD 2,STA 6, TORS MOM	IN-LB
1020	RTR 1,BLD 3,STA 6, TORS MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1021	RTR 1,BLD 4,STA 6, TORS MOM	IN-LB
1022	RTR 1,BLD 5,STA 6, TORS MOM	IN-LB
1023	RTR 1,BLD 6,STA 6, TORS MOM	IN-LB
1024	RTR 1,BLD 7,STA 6, TORS MOM	IN-LB
1025	RTR 1,BLD 1,STA 5, TORS MOM	IN-LB
1026	RTR 1,BLD 2,STA 5, TORS MOM	IN-LB
1027	RTR 1,BLD 3,STA 5, TORS MOM	IN-LB
1028	RTR 1,BLD 4,STA 5, TORS MOM	IN-LB
1029	RTR 1,BLD 5,STA 5, TORS MOM	IN-LB
1030	RTR 1,BLD 6,STA 5, TORS MOM	IN-LB
1031	RTR 1,BLD 7,STA 5, TORS MOM	IN-LB
1032	RTR 1,BLD 1,STA 4 TORS MOM	IN-LB
1033	RTR 1,BLD 2,STA 4 TORS MOM	IN-LB
1034	RTR 1,BLD 3,STA 4 TORS MOM	IN-LB
1035	RTR 1,BLD 4,STA 4 TORS MOM	IN-LB
1036	RTR 1,BLD 5,STA 4 TORS MOM	IN-LB
1037	RTR 1,BLD 6,STA 4 TORS MOM	IN-LB
1038	RTR 1,BLD 7,STA 4 TORS MOM	IN-LB
1039	RTR 1,BLD 1,STA 3 TORS MOM	IN-LB
1040	RTR 1,BLD 2,STA 3 TORS MOM	IN-LB
1041	RTR 1,BLD 3,STA 3 TORS MOM	IN-LB
1042	RTR 1,BLD 4,STA 3 TORS MOM	IN-LB
1043	RTR 1,BLD 5,STA 3 TORS MOM	IN-LB
1044	RTR 1,BLD 6,STA 3 TORS MOM	IN-LB
1045	RTR 1,BLD 7,STA 3 TORS MOM	IN-LB
1046	RTR 1,BLD 1,STA 2 TORS MOM	IN-LB
1047	RTR 1,BLD 2,STA 2 TORS MOM	IN-LB
1048	RTR 1,BLD 3,STA 2 TORS MOM	IN-LB
1049	RTR 1,BLD 4,STA 2 TORS MOM	IN-LB
1050	RTR 1,BLD 5,STA 2 TORS MOM	IN-LB
1051	RTR 1,BLD 6,STA 2 TORS MOM	IN-LB
1052	RTR 1,BLD 7,STA 2 TORS MOM	IN-LB
1053	RTR 1,BLD 1,STA 1 TORS MOM	IN-LB
1054	RTR 1,BLD 2,STA 1 TORS MOM	IN-LB
1055	RTR 1,BLD 3,STA 1 TORS MOM	IN-LB
1056	RTR 1,BLD 4,STA 1 TORS MOM	IN-LB
1057	RTR 1,BLD 5,STA 1 TORS MOM	IN-LB
1058	RTR 1,BLD 6,STA 1 TORS MOM	IN-LB
1059	RTR 1,BLD 7,STA 1 TORS MOM	IN-LB
1060	RTR 1,BLD 1,STA 0, TORS MOM	IN-LB
1061	RTR 1,BLD 2,STA 0, TORS MOM	IN-LB
1062	RTR 1,BLD 3,STA 0, TORS MOM	IN-LB
1063	RTR 1,BLD 4,STA 0, TORS MOM	IN-LB
1064	RTR 1,BLD 5,STA 0, TORS MOM	IN-LB
1065	RTR 1,BLD 6,STA 0, TORS MOM	IN-LB
1066	RTR 1,BLD 7,STA 0, TORS MOM	IN-LB
1067	RTR 2,BLD 1,STA 20, BEAM BEND MOM	IN-LB
1068	RTR 2,BLD 2,STA 20, BEAM BEND MOM	IN-LB
1069	RTR 2,BLD 3,STA 20, BEAM BEND MOM	IN-LB
1070	RTR 2,BLD 4,STA 20, BEAM BEND MOM	IN-LB
1071	RTR 2,BLD 5,STA 20, BEAM BEND MOM	IN-LB
1072	RTR 2,BLD 6,STA 20, BEAM BEND MOM	IN-LB
1073	RTR 2,BLD 7,STA 20, BEAM BEND MOM	IN-LB
1074	RTR 2,BLD 1,STA 19, BEAM BEND MOM	IN-LB
1075	RTR 2,BLD 2,STA 19, BEAM BEND MOM	IN-LB
1076	RTR 2,BLD 3,STA 19, BEAM BEND MOM	IN-LB
1077	RTR 2,BLD 4,STA 19, BEAM BEND MOM	IN-LB
1078	RTR 2,BLD 5,STA 19, BEAM BEND MOM	IN-LB
1079	RTR 2,BLD 6,STA 19, BEAM BEND MOM	IN-LB
1080	RTR 2,BLD 7,STA 19, BEAM BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1081	RTR 2,BLD 1,STA 18. BEAM BEND MOM	IN-LB
1082	RTR 2,BLD 2,STA 18. BEAM BEND MOM	IN-LB
1083	RTR 2,BLD 3,STA 18. BEAM BEND MOM	IN-LB
1084	RTR 2,BLD 4,STA 18. BEAM BEND MOM	IN-LB
1085	RTR 2,BLD 5,STA 18. BEAM BEND MOM	IN-LB
1086	RTR 2,BLD 6,STA 18. BEAM BEND MOM	IN-LB
1087	RTR 2,BLD 7,STA 18. BEAM BEND MOM	IN-LB
1088	RTR 2,BLD 1,STA 17. BEAM BEND MOM	IN-LB
1089	RTR 2,BLD 2,STA 17. BEAM BEND MOM	IN-LB
1090	RTR 2,BLD 3,STA 17. BEAM BEND MOM	IN-LB
1091	RTR 2,BLD 4,STA 17. BEAM BEND MOM	IN-LB
1092	RTR 2,BLD 5,STA 17. BEAM BEND MOM	IN-LB
1093	RTR 2,BLD 6,STA 17. BEAM BEND MOM	IN-LB
1094	RTR 2,BLD 7,STA 17. BEAM BEND MOM	IN-LB
1095	RTR 2,BLD 1,STA 16. BEAM BEND MOM	IN-LB
1096	RTR 2,BLD 2,STA 16. BEAM BEND MOM	IN-LB
1097	RTR 2,BLD 3,STA 16. BEAM BEND MOM	IN-LB
1098	RTR 2,BLD 4,STA 16. BEAM BEND MOM	IN-LB
1099	RTR 2,BLD 5,STA 16. BEAM BEND MOM	IN-LB
1100	RTR 2,BLD 6,STA 16. BEAM BEND MOM	IN-LB
1101	RTR 2,BLD 7,STA 16. BEAM BEND MOM	IN-LB
1102	RTR 2,BLD 1,STA 15. BEAM BEND MOM	IN-LB
1103	RTR 2,BLD 2,STA 15. BEAM BEND MOM	IN-LB
1104	RTR 2,BLD 3,STA 15. BEAM BEND MOM	IN-LB
1105	RTR 2,BLD 4,STA 15. BEAM BEND MOM	IN-LB
1106	RTR 2,BLD 5,STA 15. BEAM BEND MOM	IN-LB
1107	RTR 2,BLD 6,STA 15. BEAM BEND MOM	IN-LB
1108	RTR 2,BLD 7,STA 15. BEAM BEND MOM	IN-LB
1109	RTR 2,BLD 1,STA 14. BEAM BEND MOM	IN-LB
1110	RTR 2,BLD 2,STA 14. BEAM BEND MOM	IN-LB
1111	RTR 2,BLD 3,STA 14. BEAM BEND MOM	IN-LB
1112	RTR 2,BLD 4,STA 14. BEAM BEND MOM	IN-LB
1113	RTR 2,BLD 5,STA 14. BEAM BEND MOM	IN-LB
1114	RTR 2,BLD 6,STA 14. BEAM BEND MOM	IN-LB
1115	RTR 2,BLD 7,STA 14. BEAM BEND MOM	IN-LB
1116	RTR 2,BLD 1,STA 13. BEAM BEND MOM	IN-LB
1117	RTR 2,BLD 2,STA 13. BEAM BEND MOM	IN-LB
1118	RTR 2,BLD 3,STA 13. BEAM BEND MOM	IN-LB
1119	RTR 2,BLD 4,STA 13. BEAM BEND MOM	IN-LB
1120	RTR 2,BLD 5,STA 13. BEAM BEND MOM	IN-LB
1121	RTR 2,BLD 6,STA 13. BEAM BEND MOM	IN-LB
1122	RTR 2,BLD 7,STA 13. BEAM BEND MOM	IN-LB
1123	RTR 2,BLD 1,STA 12. BEAM BEND MOM	IN-LB
1124	RTR 2,BLD 2,STA 12. BEAM BEND MOM	IN-LB
1125	RTR 2,BLD 3,STA 12. BEAM BEND MOM	IN-LB
1126	RTR 2,BLD 4,STA 12. BEAM BEND MOM	IN-LB
1127	RTR 2,BLD 5,STA 12. BEAM BEND MOM	IN-LB
1128	RTR 2,BLD 6,STA 12. BEAM BEND MOM	IN-LB
1129	RTR 2,BLD 7,STA 12. BEAM BEND MOM	IN-LB
1130	RTR 2,BLD 1,STA 11. BEAM BEND MOM	IN-LB
1131	RTR 2,BLD 2,STA 11. BEAM BEND MOM	IN-LB
1132	RTR 2,BLD 3,STA 11. BEAM BEND MOM	IN-LB
1133	RTR 2,BLD 4,STA 11. BEAM BEND MOM	IN-LB
1134	RTR 2,BLD 5,STA 11. BEAM BEND MOM	IN-LB
1135	RTR 2,BLD 6,STA 11. BEAM BEND MOM	IN-LB
1136	RTR 2,BLD 7,STA 11. BEAM BEND MOM	IN-LB
1137	RTR 2,BLD 1,STA 10. BEAM BEND MOM	IN-LB
1138	RTR 2,BLD 2,STA 10. BEAM BEND MOM	IN-LB
1139	RTR 2,BLD 3,STA 10. BEAM BEND MOM	IN-LB
1140	RTR 2,BLD 4,STA 10. BEAM BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1141	RTR 2,BLD 5,STA 10, BEAM BEND MOM	IN-LB
1142	RTR 2,BLD 6,STA 10, BEAM BEND MOM	IN-LB
1143	RTR 2,BLD 7,STA 10, BEAM BEND MOM	IN-LB
1144	RTR 2,BLD 1,STA 9, BEAM BEND MOM	IN-LB
1145	RTR 2,BLD 2,STA 9, BEAM BEND MOM	IN-LB
1146	RTR 2,BLD 3,STA 9, BEAM BEND MOM	IN-LB
1147	RTR 2,BLD 4,STA 9, BEAM BEND MOM	IN-LB
1148	RTR 2,BLD 5,STA 9, BEAM BEND MOM	IN-LB
1149	RTR 2,BLD 6,STA 9, BEAM BEND MOM	IN-LB
1150	RTR 2,BLD 7,STA 9, BEAM BEND MOM	IN-LB
1151	RTR 2,BLD 1,STA 8, BEAM BEND MOM	IN-LB
1152	RTR 2,BLD 2,STA 8, BEAM BEND MOM	IN-LB
1153	RTR 2,BLD 3,STA 8, BEAM BEND MOM	IN-LB
1154	RTR 2,BLD 4,STA 8, BEAM BEND MOM	IN-LB
1155	RTR 2,BLD 5,STA 8, BEAM BEND MOM	IN-LB
1156	RTR 2,BLD 6,STA 8, BEAM BEND MOM	IN-LB
1157	RTR 2,BLD 7,STA 8, BEAM BEND MOM	IN-LB
1158	RTR 2,BLD 1,STA 7, BEAM BEND MOM	IN-LB
1159	RTR 2,BLD 2,STA 7, BEAM BEND MOM	IN-LB
1160	RTR 2,BLD 3,STA 7, BEAM BEND MOM	IN-LB
1161	RTR 2,BLD 4,STA 7, BEAM BEND MOM	IN-LB
1162	RTR 2,BLD 5,STA 7, BEAM BEND MOM	IN-LB
1163	RTR 2,BLD 6,STA 7, BEAM BEND MOM	IN-LB
1164	RTR 2,BLD 7,STA 7, BEAM BEND MOM	IN-LB
1165	RTR 2,BLD 1,STA 6, BEAM BEND MOM	IN-LB
1166	RTR 2,BLD 2,STA 6, BEAM BEND MOM	IN-LB
1167	RTR 2,BLD 3,STA 6, BEAM BEND MOM	IN-LB
1168	RTR 2,BLD 4,STA 6, BEAM BEND MOM	IN-LB
1169	RTR 2,BLD 5,STA 6, BEAM BEND MOM	IN-LB
1170	RTR 2,BLD 6,STA 6, BEAM BEND MOM	IN-LB
1171	RTR 2,BLD 7,STA 6, BEAM BEND MOM	IN-LB
1172	RTR 2,BLD 1,STA 5, BEAM BEND MOM	IN-LB
1173	RTR 2,BLD 2,STA 5, BEAM BEND MOM	IN-LB
1174	RTR 2,BLD 3,STA 5, BEAM BEND MOM	IN-LB
1175	RTR 2,BLD 4,STA 5, BEAM BEND MOM	IN-LB
1176	RTR 2,BLD 5,STA 5, BEAM BEND MOM	IN-LB
1177	RTR 2,BLD 6,STA 5, BEAM BEND MOM	IN-LB
1178	RTR 2,BLD 7,STA 5, BEAM BEND MOM	IN-LB
1179	RTR 2,BLD 1,STA 4 BEAM BEND MOM	IN-LB
1180	RTR 2,BLD 2,STA 4 BEAM BEND MOM	IN-LB
1181	RTR 2,BLD 3,STA 4 BEAM BEND MOM	IN-LB
1182	RTR 2,BLD 4,STA 4 BEAM BEND MOM	IN-LB
1183	RTR 2,BLD 5,STA 4 BEAM BEND MOM	IN-LB
1184	RTR 2,BLD 6,STA 4 BEAM BEND MOM	IN-LB
1185	RTR 2,BLD 7,STA 4 BEAM BEND MOM	IN-LB
1186	RTR 2,BLD 1,STA 3 BEAM BEND MOM	IN-LB
1187	RTR 2,BLD 2,STA 3 BEAM BEND MOM	IN-LB
1188	RTR 2,BLD 3,STA 3 BEAM BEND MOM	IN-LB
1189	RTR 2,BLD 4,STA 3 BEAM BEND MOM	IN-LB
1190	RTR 2,BLD 5,STA 3 BEAM BEND MOM	IN-LB
1191	RTR 2,BLD 6,STA 3 BEAM BEND MOM	IN-LB
1192	RTR 2,BLD 7,STA 3 BEAM BEND MOM	IN-LB
1193	RTR 2,BLD 1,STA 2 BEAM BEND MOM	IN-LB
1194	RTR 2,BLD 2,STA 2 BEAM BEND MOM	IN-LB
1195	RTR 2,BLD 3,STA 2 BEAM BEND MOM	IN-LB
1196	RTR 2,BLD 4,STA 2 BEAM BEND MOM	IN-LB
1197	RTR 2,BLD 5,STA 2 BEAM BEND MOM	IN-LB
1198	RTR 2,BLD 6,STA 2 BEAM BEND MOM	IN-LB
1199	RTR 2,BLD 7,STA 2 BEAM BEND MOM	IN-LB
1200	RTR 2,BLD 1,STA 1 BEAM BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1201	RTR 2,BLD 2,STA 1 BEAM BEND MOM	IN-LB
1202	RTR 2,BLD 3,STA 1 BEAM BEND MOM	IN-LB
1203	RTR 2,BLD 4,STA 1 BEAM BEND MOM	IN-LB
1204	RTR 2,BLD 5,STA 1 BEAM BEND MOM	IN-LB
1205	RTR 2,BLD 6,STA 1 BEAM BEND MOM	IN-LB
1206	RTR 2,BLD 7,STA 1 BEAM BEND MOM	IN-LB
1207	RTR 2,BLD 1,STA 0. BEAM BEND MOM	IN-LB
1208	RTR 2,BLD 2,STA 0. BEAM BEND MOM	IN-LB
1209	RTR 2,BLD 3,STA 0. BEAM BEND MOM	IN-LB
1210	RTR 2,BLD 4,STA 0. BEAM BEND MOM	IN-LB
1211	RTR 2,BLD 5,STA 0. BEAM BEND MOM	IN-LB
1212	RTR 2,BLD 6,STA 0. BEAM BEND MOM	IN-LB
1213	RTR 2,BLD 7,STA 0. BEAM BEND MOM	IN-LB
1214	RTR 2,BLD 1,STA 20. CHRD BEND MOM	IN-LB
1215	RTR 2,BLD 2,STA 20. CHRD BEND MOM	IN-LB
1216	RTR 2,BLD 3,STA 20. CHRD BEND MOM	IN-LB
1217	RTR 2,BLD 4,STA 20. CHRD BEND MOM	IN-LB
1218	RTR 2,BLD 5,STA 20. CHRD BEND MOM	IN-LB
1219	RTR 2,BLD 6,STA 20. CHRD BEND MOM	IN-LB
1220	RTR 2,BLD 7,STA 20. CHRD BEND MOM	IN-LB
1221	RTR 2,BLD 1,STA 19. CHRD BEND MOM	IN-LB
1222	RTR 2,BLD 2,STA 19. CHRD BEND MOM	IN-LB
1223	RTR 2,BLD 3,STA 19. CHRD BEND MOM	IN-LB
1224	RTR 2,BLD 4,STA 19. CHRD BEND MOM	IN-LB
1225	RTR 2,BLD 5,STA 19. CHRD BEND MOM	IN-LB
1226	RTR 2,BLD 6,STA 19. CHRD BEND MOM	IN-LB
1227	RTR 2,BLD 7,STA 19. CHRD BEND MOM	IN-LB
1228	RTR 2,BLD 1,STA 18. CHRD BEND MOM	IN-LB
1229	RTR 2,BLD 2,STA 18. CHRD BEND MOM	IN-LB
1230	RTR 2,BLD 3,STA 18. CHRD BEND MOM	IN-LB
1231	RTR 2,BLD 4,STA 18. CHRD BEND MOM	IN-LB
1232	RTR 2,BLD 5,STA 18. CHRD BEND MOM	IN-LB
1233	RTR 2,BLD 6,STA 18. CHRD BEND MOM	IN-LB
1234	RTR 2,BLD 7,STA 18. CHRD BEND MOM	IN-LB
1235	RTR 2,BLD 1,STA 17. CHRD BEND MOM	IN-LB
1236	RTR 2,BLD 2,STA 17. CHRD BEND MOM	IN-LB
1237	RTR 2,BLD 3,STA 17. CHRD BEND MOM	IN-LB
1238	RTR 2,BLD 4,STA 17. CHRD BEND MOM	IN-LB
1239	RTR 2,BLD 5,STA 17. CHRD BEND MOM	IN-LB
1240	RTR 2,BLD 6,STA 17. CHRD BEND MOM	IN-LB
1241	RTR 2,BLD 7,STA 17. CHRD BEND MOM	IN-LB
1242	RTR 2,BLD 1,STA 16. CHRD BEND MOM	IN-LB
1243	RTR 2,BLD 2,STA 16. CHRD BEND MOM	IN-LB
1244	RTR 2,BLD 3,STA 16. CHRD BEND MOM	IN-LB
1245	RTR 2,BLD 4,STA 16. CHRD BEND MOM	IN-LB
1246	RTR 2,BLD 5,STA 16. CHRD BEND MOM	IN-LB
1247	RTR 2,BLD 6,STA 16. CHRD BEND MOM	IN-LB
1248	RTR 2,BLD 7,STA 16. CHRD BEND MOM	IN-LB
1249	RTR 2,BLD 1,STA 15. CHRD BEND MOM	IN-LB
1250	RTR 2,BLD 2,STA 15. CHRD BEND MOM	IN-LB
1251	RTR 2,BLD 3,STA 15. CHRD BEND MOM	IN-LB
1252	RTR 2,BLD 4,STA 15. CHRD BEND MOM	IN-LB
1253	RTR 2,BLD 5,STA 15. CHRD BEND MOM	IN-LB
1254	RTR 2,BLD 6,STA 15. CHRD BEND MOM	IN-LB
1255	RTR 2,BLD 7,STA 15. CHRD BEND MOM	IN-LB
1256	RTR 2,BLD 1,STA 14. CHRD BEND MOM	IN-LB
1257	RTR 2,BLD 2,STA 14. CHRD BEND MOM	IN-LB
1258	RTR 2,BLD 3,STA 14. CHRD BEND MOM	IN-LB
1259	RTR 2,BLD 4,STA 14. CHRD BEND MOM	IN-LB
1260	RTR 2,BLD 5,STA 14. CHRD BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1261	RTR 2.BLD 6.STA 14. CHRD BEND MOM	IN-LB
1262	RTR 2.BLD 7.STA 14. CHRD BEND MOM	IN-LB
1263	RTR 2.BLD 1.STA 13. CHRD BEND MOM	IN-LB
1264	RTR 2.BLD 2.STA 13. CHRD BEND MOM	IN-LB
1265	RTR 2.BLD 3.STA 13. CHRD BEND MOM	IN-LB
1266	RTR 2.BLD 4.STA 13. CHRD BEND MOM	IN-LB
1267	RTR 2.BLD 5.STA 13. CHRD BEND MOM	IN-LB
1268	RTR 2.BLD 6.STA 13. CHRD BEND MOM	IN-LB
1269	RTR 2.BLD 7.STA 13. CHRD BEND MOM	IN-LB
1270	RTR 2.BLD 1.STA 12. CHRD BEND MOM	IN-LB
1271	RTR 2.BLD 2.STA 12. CHRD BEND MOM	IN-LB
1272	RTR 2.BLD 3.STA 12. CHRD BEND MOM	IN-LB
1273	RTR 2.BLD 4.STA 12. CHRD BEND MOM	IN-LB
1274	RTR 2.BLD 5.STA 12. CHRD BEND MOM	IN-LB
1275	RTR 2.BLD 6.STA 12. CHRD BEND MOM	IN-LB
1276	RTR 2.BLD 7.STA 12. CHRD BEND MOM	IN-LB
1277	RTR 2.BLD 1.STA 11. CHRD BEND MOM	IN-LB
1278	RTR 2.BLD 2.STA 11. CHRD BEND MOM	IN-LB
1279	RTR 2.BLD 3.STA 11. CHRD BEND MOM	IN-LB
1280	RTR 2.BLD 4.STA 11. CHRD BEND MOM	IN-LB
1281	RTR 2.BLD 5.STA 11. CHRD BEND MOM	IN-LB
1282	RTR 2.BLD 6.STA 11. CHRD BEND MOM	IN-LB
1283	RTR 2.BLD 7.STA 11. CHRD BEND MOM	IN-LB
1284	RTR 2.BLD 1.STA 10. CHRD BEND MOM	IN-LB
1285	RTR 2.BLD 2.STA 10. CHRD BEND MOM	IN-LB
1286	RTR 2.BLD 3.STA 10. CHRD BEND MOM	IN-LB
1287	RTR 2.BLD 4.STA 10. CHRD BEND MOM	IN-LB
1288	RTR 2.BLD 5.STA 10. CHRD BEND MOM	IN-LB
1289	RTR 2.BLD 6.STA 10. CHRD BEND MOM	IN-LB
1290	RTR 2.BLD 7.STA 10. CHRD BEND MOM	IN-LB
1291	RTR 2.BLD 1.STA 9. CHRD BEND MOM	IN-LB
1292	RTR 2.BLD 2.STA 9. CHRD BEND MOM	IN-LB
1293	RTR 2.BLD 3.STA 9. CHRD BEND MOM	IN-LB
1294	RTR 2.BLD 4.STA 9. CHRD BEND MOM	IN-LB
1295	RTR 2.BLD 5.STA 9. CHRD BEND MOM	IN-LB
1296	RTR 2.BLD 6.STA 9. CHRD BEND MOM	IN-LB
1297	RTR 2.BLD 7.STA 9. CHRD BEND MOM	IN-LB
1298	RTR 2.BLD 1.STA 8. CHRD BEND MOM	IN-LB
1299	RTR 2.BLD 2.STA 8. CHRD BEND MOM	IN-LB
1300	RTR 2.BLD 3.STA 8. CHRD BEND MOM	IN-LB
1301	RTR 2.BLD 4.STA 8. CHRD BEND MOM	IN-LB
1302	RTR 2.BLD 5.STA 8. CHRD BEND MOM	IN-LB
1303	RTR 2.BLD 6.STA 8. CHRD BEND MOM	IN-LB
1304	RTR 2.BLD 7.STA 8. CHRD BEND MOM	IN-LB
1305	RTR 2.BLD 1.STA 7. CHRD BEND MOM	IN-LB
1306	RTR 2.BLD 2.STA 7. CHRD BEND MOM	IN-LB
1307	RTR 2.BLD 3.STA 7. CHRD BEND MOM	IN-LB
1308	RTR 2.BLD 4.STA 7. CHRD BEND MOM	IN-LB
1309	RTR 2.BLD 5.STA 7. CHRD BEND MOM	IN-LB
1310	RTR 2.BLD 6.STA 7. CHRD BEND MOM	IN-LB
1311	RTR 2.BLD 7.STA 7. CHRD BEND MOM	IN-LB
1312	RTR 2.BLD 1.STA 6. CHRD BEND MOM	IN-LB
1313	RTR 2.BLD 2.STA 6. CHRD BEND MOM	IN-LB
1314	RTR 2.BLD 3.STA 6. CHRD BEND MOM	IN-LB
1315	RTR 2.BLD 4.STA 6. CHRD BEND MOM	IN-LB
1316	RTR 2.BLD 5.STA 6. CHRD BEND MOM	IN-LB
1317	RTR 2.BLD 6.STA 6. CHRD BEND MOM	IN-LB
1318	RTR 2.BLD 7.STA 6. CHRD BEND MOM	IN-LB
1319	RTR 2.BLD 1.STA 5. CHRD BEND MOM	IN-LB
1320	RTR 2.BLD 2.STA 5. CHRD BEND MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1321	RTR 2.BLD 3.STA 5. CHRD BEND MOM	IN-LB
1322	RTR 2.BLD 4.STA 5. CHRD BEND MOM	IN-LB
1323	RTR 2.BLD 5.STA 5. CHRD BEND MOM	IN-LB
1324	RTR 2.BLD 6.STA 5. CHRD BEND MOM	IN-LB
1325	RTR 2.BLD 7.STA 5. CHRD BEND MOM	IN-LB
1326	RTR 2.BLD 1.STA 4 CHRD BEND MOM	IN-LB
1327	RTR 2.BLD 2.STA 4 CHRD BEND MOM	IN-LB
1328	RTR 2.BLD 3.STA 4 CHRD BEND MOM	IN-LB
1329	RTR 2.BLD 4.STA 4 CHRD BEND MOM	IN-LB
1330	RTR 2.BLD 5.STA 4 CHRD BEND MOM	IN-LB
1331	RTR 2.BLD 6.STA 4 CHRD BEND MOM	IN-LB
1332	RTR 2.BLD 7.STA 4 CHRD BEND MOM	IN-LB
1333	RTR 2.BLD 1.STA 3 CHRD BEND MOM	IN-LB
1334	RTR 2.BLD 2.STA 3 CHRD BEND MOM	IN-LB
1335	RTR 2.BLD 3.STA 3 CHRD BEND MOM	IN-LB
1336	RTR 2.BLD 4.STA 3 CHRD BEND MOM	IN-LB
1337	RTR 2.BLD 5.STA 3 CHRD BEND MOM	IN-LB
1338	RTR 2.BLD 6.STA 3 CHRD BEND MOM	IN-LB
1339	RTR 2.BLD 7.STA 3 CHRD BEND MOM	IN-LB
1340	RTR 2.BLD 1.STA 2 CHRD BEND MOM	IN-LB
1341	RTR 2.BLD 2.STA 2 CHRD BEND MOM	IN-LB
1342	RTR 2.BLD 3.STA 2 CHRD BEND MOM	IN-LB
1343	RTR 2.BLD 4.STA 2 CHRD BEND MOM	IN-LB
1344	RTR 2.BLD 5.STA 2 CHRD BEND MOM	IN-LB
1345	RTR 2.BLD 6.STA 2 CHRD BEND MOM	IN-LB
1346	RTR 2.BLD 7.STA 2 CHRD BEND MOM	IN-LB
1347	RTR 2.BLD 1.STA 1 CHRD BEND MOM	IN-LB
1348	RTR 2.BLD 2.STA 1 CHRD BEND MOM	IN-LB
1349	RTR 2.BLD 3.STA 1 CHRD BEND MOM	IN-LB
1350	RTR 2.BLD 4.STA 1 CHRD BEND MOM	IN-LB
1351	RTR 2.BLD 5.STA 1 CHRD BEND MOM	IN-LB
1352	RTR 2.BLD 6.STA 1 CHRD BEND MOM	IN-LB
1353	RTR 2.BLD 7.STA 1 CHRD BEND MOM	IN-LB
1354	RTR 2.BLD 1.STA 0. CHRD BEND MOM	IN-LB
1355	RTR 2.BLD 2.STA 0. CHRD BEND MOM	IN-LB
1356	RTR 2.BLD 3.STA 0. CHRD BEND MOM	IN-LB
1357	RTR 2.BLD 4.STA 0. CHRD BEND MOM	IN-LB
1358	RTR 2.BLD 5.STA 0. CHRD BEND MOM	IN-LB
1359	RTR 2.BLD 6.STA 0. CHRD BEND MOM	IN-LB
1360	RTR 2.BLD 7.STA 0. CHRD BEND MOM	IN-LB
1361	RTR 2.BLD 1.STA 20. TORS MOM	IN-LB
1362	RTR 2.BLD 2.STA 20. TORS MOM	IN-LB
1363	RTR 2.BLD 3.STA 20. TORS MOM	IN-LB
1364	RTR 2.BLD 4.STA 20. TORS MOM	IN-LB
1365	RTR 2.BLD 5.STA 20. TORS MOM	IN-LB
1366	RTR 2.BLD 6.STA 20. TORS MOM	IN-LB
1367	RTR 2.BLD 7.STA 20. TORS MOM	IN-LB
1368	RTR 2.BLD 1.STA 19. TORS MOM	IN-LB
1369	RTR 2.BLD 2.STA 19. TORS MOM	IN-LB
1370	RTR 2.BLD 3.STA 19. TORS MOM	IN-LB
1371	RTR 2.BLD 4.STA 19. TORS MOM	IN-LB
1372	RTR 2.BLD 5.STA 19. TORS MOM	IN-LB
1373	RTR 2.BLD 6.STA 19. TORS MOM	IN-LB
1374	RTR 2.BLD 7.STA 19. TORS MOM	IN-LB
1375	RTR 2.BLD 1.STA 18. TORS MOM	IN-LB
1376	RTR 2.BLD 2.STA 18. TORS MOM	IN-LB
1377	RTR 2.BLD 3.STA 18. TORS MOM	IN-LB
1378	RTR 2.BLD 4.STA 18. TORS MOM	IN-LB
1379	RTR 2.BLD 5.STA 18. TORS MOM	IN-LB
1380	RTR 2.BLD 6.STA 18. TORS MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1381	RTR 2.BLD 7.STA 18. TORS MOM	IN-LB
1382	RTR 2.BLD 1.STA 17. TORS MOM	IN-LB
1383	RTR 2.BLD 2.STA 17. TORS MOM	IN-LB
1384	RTR 2.BLD 3.STA 17. TORS MOM	IN-LB
1385	RTR 2.BLD 4.STA 17. TORS MOM	IN-LB
1386	RTR 2.BLD 5.STA 17. TORS MOM	IN-LB
1387	RTR 2.BLD 6.STA 17. TORS MOM	IN-LB
1388	RTR 2.BLD 7.STA 17. TORS MOM	IN-LB
1389	RTR 2.BLD 1.STA 16. TORS MOM	IN-LB
1390	RTR 2.BLD 2.STA 16. TORS MOM	IN-LB
1391	RTR 2.BLD 3.STA 16. TORS MOM	IN-LB
1392	RTR 2.BLD 4.STA 16. TORS MOM	IN-LB
1393	RTR 2.BLD 5.STA 16. TORS MOM	IN-LB
1394	RTR 2.BLD 6.STA 16. TORS MOM	IN-LB
1395	RTR 2.BLD 7.STA 16. TORS MOM	IN-LB
1396	RTR 2.BLD 1.STA 15. TORS MOM	IN-LB
1397	RTR 2.BLD 2.STA 15. TORS MOM	IN-LB
1398	RTR 2.BLD 3.STA 15. TORS MOM	IN-LB
1399	RTR 2.BLD 4.STA 15. TORS MOM	IN-LB
1400	RTR 2.BLD 5.STA 15. TORS MOM	IN-LB
1401	RTR 2.BLD 6.STA 15. TORS MOM	IN-LB
1402	RTR 2.BLD 7.STA 15. TORS MOM	IN-LB
1403	RTR 2.BLD 1.STA 14. TORS MOM	IN-LB
1404	RTR 2.BLD 2.STA 14. TORS MOM	IN-LB
1405	RTR 2.BLD 3.STA 14. TORS MOM	IN-LB
1406	RTR 2.BLD 4.STA 14. TORS MOM	IN-LB
1407	RTR 2.BLD 5.STA 14. TORS MOM	IN-LB
1408	RTR 2.BLD 6.STA 14. TORS MOM	IN-LB
1409	RTR 2.BLD 7.STA 14. TORS MOM	IN-LB
1410	RTR 2.BLD 1.STA 13. TORS MOM	IN-LB
1411	RTR 2.BLD 2.STA 13. TORS MOM	IN-LB
1412	RTR 2.BLD 3.STA 13. TORS MOM	IN-LB
1413	RTR 2.BLD 4.STA 13. TORS MOM	IN-LB
1414	RTR 2.BLD 5.STA 13. TORS MOM	IN-LB
1415	RTR 2.BLD 6.STA 13. TORS MOM	IN-LB
1416	RTR 2.BLD 7.STA 13. TORS MOM	IN-LB
1417	RTR 2.BLD 1.STA 12. TORS MOM	IN-LB
1418	RTR 2.BLD 2.STA 12. TORS MOM	IN-LB
1419	RTR 2.BLD 3.STA 12. TORS MOM	IN-LB
1420	RTR 2.BLD 4.STA 12. TORS MOM	IN-LB
1421	RTR 2.BLD 5.STA 12. TORS MOM	IN-LB
1422	RTR 2.BLD 6.STA 12. TORS MOM	IN-LB
1423	RTR 2.BLD 7.STA 12. TORS MOM	IN-LB
1424	RTR 2.BLD 1.STA 11. TORS MOM	IN-LB
1425	RTR 2.BLD 2.STA 11. TORS MOM	IN-LB
1426	RTR 2.BLD 3.STA 11. TORS MOM	IN-LB
1427	RTR 2.BLD 4.STA 11. TORS MOM	IN-LB
1428	RTR 2.BLD 5.STA 11. TORS MOM	IN-LB
1429	RTR 2.BLD 6.STA 11. TORS MOM	IN-LB
1430	RTR 2.BLD 7.STA 11. TORS MOM	IN-LB
1431	RTR 2.BLD 1.STA 10. TORS MOM	IN-LB
1432	RTR 2.BLD 2.STA 10. TORS MOM	IN-LB
1433	RTR 2.BLD 3.STA 10. TORS MOM	IN-LB
1434	RTR 2.BLD 4.STA 10. TORS MOM	IN-LB
1435	RTR 2.BLD 5.STA 10. TORS MOM	IN-LB
1436	RTR 2.BLD 6.STA 10. TORS MOM	IN-LB
1437	RTR 2.BLD 7.STA 10. TORS MOM	IN-LB
1438	RTR 2.BLD 1.STA 9. TORS MOM	IN-LB
1439	RTR 2.BLD 2.STA 9. TORS MOM	IN-LB
1440	RTR 2.BLD 3.STA 9. TORS MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1441	RTR 2.BLD 4.STA 9. TORS MOM	IN-LB
1442	RTR 2.BLD 5.STA 9. TORS MOM	IN-LB
1443	RTR 2.BLD 6.STA 9. TORS MOM	IN-LB
1444	RTR 2.BLD 7.STA 9. TORS MOM	IN-LB
1445	RTR 2.BLD 1.STA 8. TORS MOM	IN-LB
1446	RTR 2.BLD 2.STA 8. TORS MOM	IN-LB
1447	RTR 2.BLD 3.STA 8. TORS MOM	IN-LB
1448	RTR 2.BLD 4.STA 8. TORS MOM	IN-LB
1449	RTR 2.BLD 5.STA 8. TORS MOM	IN-LB
1450	RTR 2.BLD 6.STA 8. TORS MOM	IN-LB
1451	RTR 2.BLD 7.STA 8. TORS MOM	IN-LB
1452	RTR 2.BLD 1.STA 7. TORS MOM	IN-LB
1453	RTR 2.BLD 2.STA 7. TORS MOM	IN-LB
1454	RTR 2.BLD 3.STA 7. TORS MOM	IN-LB
1455	RTR 2.BLD 4.STA 7. TORS MOM	IN-LB
1456	RTR 2.BLD 5.STA 7. TORS MOM	IN-LB
1457	RTR 2.BLD 6.STA 7. TORS MOM	IN-LB
1458	RTR 2.BLD 7.STA 7. TORS MOM	IN-LB
1459	RTR 2.BLD 1.STA 6. TORS MOM	IN-LB
1460	RTR 2.BLD 2.STA 6. TORS MOM	IN-LB
1461	RTR 2.BLD 3.STA 6. TORS MOM	IN-LB
1462	RTR 2.BLD 4.STA 6. TORS MOM	IN-LB
1463	RTR 2.BLD 5.STA 6. TORS MOM	IN-LB
1464	RTR 2.BLD 6.STA 6. TORS MOM	IN-LB
1465	RTR 2.BLD 7.STA 6. TORS MOM	IN-LB
1466	RTR 2.BLD 1.STA 5. TORS MOM	IN-LB
1467	RTR 2.BLD 2.STA 5. TORS MOM	IN-LB
1468	RTR 2.BLD 3.STA 5. TORS MOM	IN-LB
1469	RTR 2.BLD 4.STA 5. TORS MOM	IN-LB
1470	RTR 2.BLD 5.STA 5. TORS MOM	IN-LB
1471	RTR 2.BLD 6.STA 5. TORS MOM	IN-LB
1472	RTR 2.BLD 7.STA 5. TORS MOM	IN-LB
1473	RTR 2.BLD 1.STA 4 TORS MOM	IN-LB
1474	RTR 2.BLD 2.STA 4 TORS MOM	IN-LB
1475	RTR 2.BLD 3.STA 4 TORS MOM	IN-LB
1476	RTR 2.BLD 4.STA 4 TORS MOM	IN-LB
1477	RTR 2.BLD 5.STA 4 TORS MOM	IN-LB
1478	RTR 2.BLD 6.STA 4 TORS MOM	IN-LB
1479	RTR 2.BLD 7.STA 4 TORS MOM	IN-LB
1480	RTR 2.BLD 1.STA 3 TORS MOM	IN-LB
1481	RTR 2.BLD 2.STA 3 TORS MOM	IN-LB
1482	RTR 2.BLD 3.STA 3 TORS MOM	IN-LB
1483	RTR 2.BLD 4.STA 3 TORS MOM	IN-LB
1484	RTR 2.BLD 5.STA 3 TORS MOM	IN-LB
1485	RTR 2.BLD 6.STA 3 TORS MOM	IN-LB
1486	RTR 2.BLD 7.STA 3 TORS MOM	IN-LB
1487	RTR 2.BLD 1.STA 2 TORS MOM	IN-LB
1488	RTR 2.BLD 2.STA 2 TORS MOM	IN-LB
1489	RTR 2.BLD 3.STA 2 TORS MOM	IN-LB
1490	RTR 2.BLD 4.STA 2 TORS MOM	IN-LB
1491	RTR 2.BLD 5.STA 2 TORS MOM	IN-LB
1492	RTR 2.BLD 6.STA 2 TORS MOM	IN-LB
1493	RTR 2.BLD 7.STA 2 TORS MOM	IN-LB
1494	RTR 2.BLD 1.STA 1 TORS MOM	IN-LB
1495	RTR 2.BLD 2.STA 1 TORS MOM	IN-LB
1496	RTR 2.BLD 3.STA 1 TORS MOM	IN-LB
1497	RTR 2.BLD 4.STA 1 TORS MOM	IN-LB
1498	RTR 2.BLD 5.STA 1 TORS MOM	IN-LB
1499	RTR 2.BLD 6.STA 1 TORS MOM	IN-LB
1500	RTR 2.BLD 7.STA 1 TORS MOM	IN-LB

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1501	RTR 2,BLD 1,STA 0, TORS MOM	IN-LB
1502	RTR 2,BLD 2,STA 0, TORS MOM	IN-LB
1503	RTR 2,BLD 3,STA 0, TORS MOM	IN-LB
1504	RTR 2,BLD 4,STA 0, TORS MOM	IN-LB
1505	RTR 2,BLD 5,STA 0, TORS MOM	IN-LB
1506	RTR 2,BLD 6,STA 0, TORS MOM	IN-LB
1507	RTR 2,BLD 7,STA 0, TORS MOM	IN-LB
1508	GEN.COORD., PYLON 1, MODE 1	
1509	GEN.COORD., PYLON 1, MODE 2	
1510	GEN.COORD., PYLON 1, MODE 3	
1511	GEN.COORD., PYLON 1, MODE 4	
1512	GEN.COORD., PYLON 1, MODE 5	
1513	GEN.COORD., PYLON 1, MODE 6	
1514	GEN.COORD., PYLON 1, MODE 7	
1515	GEN.COORD., PYLON 1, MODE 8	
1516	GEN.COORD., PYLON 1, MODE 9	
1517	GEN.COORD., PYLON 1, MODE 10	
1518	GEN.COORD., PYLON 2, MODE 1	
1519	GEN.COORD., PYLON 2, MODE 2	
1520	GEN.COORD., PYLON 2, MODE 3	
1521	GEN.COORD., PYLON 2, MODE 4	
1522	GEN.COORD., PYLON 2, MODE 5	
1523	GEN.COORD., PYLON 2, MODE 6	
1524	GEN.COORD., PYLON 2, MODE 7	
1525	GEN.COORD., PYLON 2, MODE 8	
1526	GEN.COORD., PYLON 2, MODE 9	
1527	GEN.COORD., PYLON 2, MODE 10	
1528	PYLON 1, X-DISP., SHAFT AXES	FEET
1529	PYLON 1, Y-DISP., SHAFT AXES	FEET
1530	PYLON 1, Z-DISP., SHAFT AXES	FEET
1531	PYLON 1, X-ANGLE, SHAFT AXES	DEGREES
1532	PYLON 1, Y-ANGLE, SHAFT AXES	DEGREES
1533	PYLON 1, Z-ANGLE, SHAFT AXES	DEGREES
1534	PYLON 2, X-DISP., SHAFT AXES	FEET
1535	PYLON 2, Y-DISP., SHAFT AXES	FEET
1536	PYLON 2, Z-DISP., SHAFT AXES	FEET
1537	PYLON 2, X-ANGLE, SHAFT AXES	DEGREES
1538	PYLON 2, Y-ANGLE, SHAFT AXES	DEGREES
1539	PYLON 2, Z-ANGLE, SHAFT AXES	DEGREES
1540	RTR 1, BLD 1, PITCH LINK TENSION	POUNDS
1541	RTR 1, BLD 2, PITCH LINK TENSION	POUNDS
1542	RTR 1, BLD 3, PITCH LINK TENSION	POUNDS
1543	RTR 1, BLD 4, PITCH LINK TENSION	POUNDS
1544	RTR 1, BLD 5, PITCH LINK TENSION	POUNDS
1545	RTR 1, BLD 6, PITCH LINK TENSION	POUNDS
1546	RTR 1, BLD 7, PITCH LINK TENSION	POUNDS
1547	NOT USED	
1548	NOT USED	
1549	NOT USED	
1550	NOT USED	
1551	NOT USED	
1552	RTR 2, BLD 1, PITCH LINK TENSION	POUNDS
1553	RTR 2, BLD 2, PITCH LINK TENSION	POUNDS
1554	RTR 2, BLD 3, PITCH LINK TENSION	POUNDS
1555	RTR 2, BLD 4, PITCH LINK TENSION	POUNDS
1556	RTR 2, BLD 5, PITCH LINK TENSION	POUNDS
1557	RTR 2, BLD 6, PITCH LINK TENSION	POUNDS
1558	RTR 2, BLD 7, PITCH LINK TENSION	POUNDS
1559	NOT USED	
1560	NOT USED	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1561	NOT USED	
1562	NOT USED	
1563	NOT USED	
1564	PYLON 1, X-ACCELERATION, BODY AXIS	G
1565	PYLON 1, Y-ACCELERATION, BODY AXIS	G
1566	PYLON 1, Z-ACCELERATION, BODY AXIS	G
1567	PYLON 1, ROLL ACCELERATION, BODY AXIS	RAD/SEC**2
1568	PYLON 1, PITCH ACCELERATION, BODY AXIS	RAD/SEC**2
1569	PYLON 1, YAW ACCELERATION, BODY AXIS	RAD/SEC**2
1570	PYLON 2, X-ACCELERATION, BODY AXIS	G
1571	PYLON 2, Y-ACCELERATION, BODY AXIS	G
1572	PYLON 2, Z-ACCELERATION, BODY AXIS	G
1573	PYLON 2, ROLL ACCELERATION, BODY AXIS	RAD/SEC**2
1574	PYLON 2, PITCH ACCELERATION, BODY AXIS	RAD/SEC**2
1575	PYLON 2, YAW ACCELERATION, BODY AXIS	RAD/SEC**2
1576	RTR 1,BLD 1,STA 20, MACH NUMBER	
1577	RTR 1,BLD 1,STA 19, MACH NUMBER	
1578	RTR 1,BLD 1,STA 18, MACH NUMBER	
1579	RTR 1,BLD 1,STA 17, MACH NUMBER	
1580	RTR 1,BLD 1,STA 16, MACH NUMBER	
1581	RTR 1,BLD 1,STA 15, MACH NUMBER	
1582	RTR 1,BLD 1,STA 14, MACH NUMBER	
1583	RTR 1,BLD 1,STA 13, MACH NUMBER	
1584	RTR 1,BLD 1,STA 12, MACH NUMBER	
1585	RTR 1,BLD 1,STA 11, MACH NUMBER	
1586	RTR 1,BLD 1,STA 10, MACH NUMBER	
1587	RTR 1,BLD 1,STA 9, MACH NUMBER	
1588	RTR 1,BLD 1,STA 8, MACH NUMBER	
1589	RTR 1,BLD 1,STA 7, MACH NUMBER	
1590	RTR 1,BLD 1,STA 6, MACH NUMBER	
1591	RTR 1,BLD 1,STA 5, MACH NUMBER	
1592	RTR 1,BLD 1,STA 4 MACH NUMBER	
1593	RTR 1,BLD 1,STA 3 MACH NUMBER	
1594	RTR 1,BLD 1,STA 2 MACH NUMBER	
1595	RTR 1,BLD 1,STA 1 MACH NUMBER	
1596	RTR 1,BLD 1,STA 0, MACH NUMBER	
1597	RTR 1,BLD 1,STA 20, ANGLE OF ATTACK	DEGREES
1598	RTR 1,BLD 1,STA 19, ANGLE OF ATTACK	DEGREES
1599	RTR 1,BLD 1,STA 18, ANGLE OF ATTACK	DEGREES
1600	RTR 1,BLD 1,STA 17, ANGLE OF ATTACK	DEGREES
1601	RTR 1,BLD 1,STA 16, ANGLE OF ATTACK	DEGREES
1602	RTR 1,BLD 1,STA 15, ANGLE OF ATTACK	DEGREES
1603	RTR 1,BLD 1,STA 14, ANGLE OF ATTACK	DEGREES
1604	RTR 1,BLD 1,STA 13, ANGLE OF ATTACK	DEGREES
1605	RTR 1,BLD 1,STA 12, ANGLE OF ATTACK	DEGREES
1606	RTR 1,BLD 1,STA 11, ANGLE OF ATTACK	DEGREES
1607	RTR 1,BLD 1,STA 10, ANGLE OF ATTACK	DEGREES
1608	RTR 1,BLD 1,STA 9, ANGLE OF ATTACK	DEGREES
1609	RTR 1,BLD 1,STA 8, ANGLE OF ATTACK	DEGREES
1610	RTR 1,BLD 1,STA 7, ANGLE OF ATTACK	DEGREES
1611	RTR 1,BLD 1,STA 6, ANGLE OF ATTACK	DEGREES
1612	RTR 1,BLD 1,STA 5, ANGLE OF ATTACK	DEGREES
1613	RTR 1,BLD 1,STA 4 ANGLE OF ATTACK	DEGREES
1614	RTR 1,BLD 1,STA 3 ANGLE OF ATTACK	DEGREES
1615	RTR 1,BLD 1,STA 2 ANGLE OF ATTACK	DEGREES
1616	RTR 1,BLD 1,STA 1 ANGLE OF ATTACK	DEGREES
1617	RTR 1,BLD 1,STA 0, ANGLE OF ATTACK	DEGREES
1618	RTR 1,BLD 1,STA 20, TOTAL LIFT COEFFICIENT	
1619	RTR 1,BLD 1,STA 19, TOTAL LIFT COEFFICIENT	
1620	RTR 1,BLD 1,STA 18, TOTAL LIFT COEFFICIENT	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1621	RTR 1,BLD 1,STA 17, TOTAL LIFT COEFFICIENT	
1622	RTR 1,BLD 1,STA 16, TOTAL LIFT COEFFICIENT	
1623	RTR 1,BLD 1,STA 15, TOTAL LIFT COEFFICIENT	
1624	RTR 1,BLD 1,STA 14, TOTAL LIFT COEFFICIENT	
1625	RTR 1,BLD 1,STA 13, TOTAL LIFT COEFFICIENT	
1626	RTR 1,BLD 1,STA 12, TOTAL LIFT COEFFICIENT	
1627	RTR 1,BLD 1,STA 11, TOTAL LIFT COEFFICIENT	
1628	RTR 1,BLD 1,STA 10, TOTAL LIFT COEFFICIENT	
1629	RTR 1,BLD 1,STA 9, TOTAL LIFT COEFFICIENT	
1630	RTR 1,BLD 1,STA 8, TOTAL LIFT COEFFICIENT	
1631	RTR 1,BLD 1,STA 7, TOTAL LIFT COEFFICIENT	
1632	RTR 1,BLD 1,STA 6, TOTAL LIFT COEFFICIENT	
1633	RTR 1,BLD 1,STA 5, TOTAL LIFT COEFFICIENT	
1634	RTR 1,BLD 1,STA 4 TOTAL LIFT COEFFICIENT	
1635	RTR 1,BLD 1,STA 3 TOTAL LIFT COEFFICIENT	
1636	RTR 1,BLD 1,STA 2 TOTAL LIFT COEFFICIENT	
1637	RTR 1,BLD 1,STA 1 TOTAL LIFT COEFFICIENT	
1638	RTR 1,BLD 1,STA 0, TOTAL LIFT COEFFICIENT	
1639	RTR 1,BLD 1,STA 20, UNSTEADY LIFT COEFFICIEN	
1640	RTR 1,BLD 1,STA 19, UNSTEADY LIFT COEFFICIEN	
1641	RTR 1,BLD 1,STA 18, UNSTEADY LIFT COEFFICIEN	
1642	RTR 1,BLD 1,STA 17, UNSTEADY LIFT COEFFICIEN	
1643	RTR 1,BLD 1,STA 16, UNSTEADY LIFT COEFFICIEN	
1644	RTR 1,BLD 1,STA 15, UNSTEADY LIFT COEFFICIEN	
1645	RTR 1,BLD 1,STA 14, UNSTEADY LIFT COEFFICIEN	
1646	RTR 1,BLD 1,STA 13, UNSTEADY LIFT COEFFICIEN	
1647	RTR 1,BLD 1,STA 12, UNSTEADY LIFT COEFFICIEN	
1648	RTR 1,BLD 1,STA 11, UNSTEADY LIFT COEFFICIEN	
1649	RTR 1,BLD 1,STA 10, UNSTEADY LIFT COEFFICIEN	
1650	RTR 1,BLD 1,STA 9, UNSTEADY LIFT COEFFICIEN	
1651	RTR 1,BLD 1,STA 8, UNSTEADY LIFT COEFFICIEN	
1652	RTR 1,BLD 1,STA 7, UNSTEADY LIFT COEFFICIEN	
1653	RTR 1,BLD 1,STA 6, UNSTEADY LIFT COEFFICIEN	
1654	RTR 1,BLD 1,STA 5, UNSTEADY LIFT COEFFICIEN	
1655	RTR 1,BLD 1,STA 4 UNSTEADY LIFT COEFFICIEN	
1656	RTR 1,BLD 1,STA 3 UNSTEADY LIFT COEFFICIEN	
1657	RTR 1,BLD 1,STA 2 UNSTEADY LIFT COEFFICIEN	
1658	RTR 1,BLD 1,STA 1 UNSTEADY LIFT COEFFICIEN	
1659	RTR 1,BLD 1,STA 0, UNSTEADY LIFT COEFFICIEN	
1660	RTR 1,BLD 1,STA 20, NORMAL FORCE COEFFICIENT	
1661	RTR 1,BLD 1,STA 19, NORMAL FORCE COEFFICIENT	
1662	RTR 1,BLD 1,STA 18, NORMAL FORCE COEFFICIENT	
1663	RTR 1,BLD 1,STA 17, NORMAL FORCE COEFFICIENT	
1664	RTR 1,BLD 1,STA 16, NORMAL FORCE COEFFICIENT	
1665	RTR 1,BLD 1,STA 15, NORMAL FORCE COEFFICIENT	
1666	RTR 1,BLD 1,STA 14, NORMAL FORCE COEFFICIENT	
1667	RTR 1,BLD 1,STA 13, NORMAL FORCE COEFFICIENT	
1668	RTR 1,BLD 1,STA 12, NORMAL FORCE COEFFICIENT	
1669	RTR 1,BLD 1,STA 11, NORMAL FORCE COEFFICIENT	
1670	RTR 1,BLD 1,STA 10, NORMAL FORCE COEFFICIENT	
1671	RTR 1,BLD 1,STA 9, NORMAL FORCE COEFFICIENT	
1672	RTR 1,BLD 1,STA 8, NORMAL FORCE COEFFICIENT	
1673	RTR 1,BLD 1,STA 7, NORMAL FORCE COEFFICIENT	
1674	RTR 1,BLD 1,STA 6, NORMAL FORCE COEFFICIENT	
1675	RTR 1,BLD 1,STA 5, NORMAL FORCE COEFFICIENT	
1676	RTR 1,BLD 1,STA 4 NORMAL FORCE COEFFICIENT	
1677	RTR 1,BLD 1,STA 3 NORMAL FORCE COEFFICIENT	
1678	RTR 1,BLD 1,STA 2 NORMAL FORCE COEFFICIENT	
1679	RTR 1,BLD 1,STA 1 NORMAL FORCE COEFFICIENT	
1680	RTR 1,BLD 1,STA 0, NORMAL FORCE COEFFICIENT	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1681	RTR 1,BLD 1,STA 20, DRAG COEFFICIENT	
1682	RTR 1,BLD 1,STA 19, DRAG COEFFICIENT	
1683	RTR 1,BLD 1,STA 18, DRAG COEFFICIENT	
1684	RTR 1,BLD 1,STA 17, DRAG COEFFICIENT	
1685	RTR 1,BLD 1,STA 16, DRAG COEFFICIENT	
1686	RTR 1,BLD 1,STA 15, DRAG COEFFICIENT	
1687	RTR 1,BLD 1,STA 14, DRAG COEFFICIENT	
1688	RTR 1,BLD 1,STA 13, DRAG COEFFICIENT	
1689	RTR 1,BLD 1,STA 12, DRAG COEFFICIENT	
1690	RTR 1,BLD 1,STA 11, DRAG COEFFICIENT	
1691	RTR 1,BLD 1,STA 10, DRAG COEFFICIENT	
1692	RTR 1,BLD 1,STA 9, DRAG COEFFICIENT	
1693	RTR 1,BLD 1,STA 8, DRAG COEFFICIENT	
1694	RTR 1,BLD 1,STA 7, DRAG COEFFICIENT	
1695	RTR 1,BLD 1,STA 6, DRAG COEFFICIENT	
1696	RTR 1,BLD 1,STA 5, DRAG COEFFICIENT	
1697	RTR 1,BLD 1,STA 4 DRAG COEFFICIENT	
1698	RTR 1,BLD 1,STA 3 DRAG COEFFICIENT	
1699	RTR 1,BLD 1,STA 2 DRAG COEFFICIENT	
1700	RTR 1,BLD 1,STA 1 DRAG COEFFICIENT	
1701	RTR 1,BLD 1,STA 0, DRAG COEFFICIENT	
1702	RTR 1,BLD 1,STA 20, CHORDWISE FORCE COEFFICI	
1703	RTR 1,BLD 1,STA 19, CHORDWISE FORCE COEFFICI	
1704	RTR 1,BLD 1,STA 18, CHORDWISE FORCE COEFFICI	
1705	RTR 1,BLD 1,STA 17, CHORDWISE FORCE COEFFICI	
1706	RTR 1,BLD 1,STA 16, CHORDWISE FORCE COEFFICI	
1707	RTR 1,BLD 1,STA 15, CHORDWISE FORCE COEFFICI	
1708	RTR 1,BLD 1,STA 14, CHORDWISE FORCE COEFFICI	
1709	RTR 1,BLD 1,STA 13, CHORDWISE FORCE COEFFICI	
1710	RTR 1,BLD 1,STA 12, CHORDWISE FORCE COEFFICI	
1711	RTR 1,BLD 1,STA 11, CHORDWISE FORCE COEFFICI	
1712	RTR 1,BLD 1,STA 10, CHORDWISE FORCE COEFFICI	
1713	RTR 1,BLD 1,STA 9, CHORDWISE FORCE COEFFICI	
1714	RTR 1,BLD 1,STA 8, CHORDWISE FORCE COEFFICI	
1715	RTR 1,BLD 1,STA 7, CHORDWISE FORCE COEFFICI	
1716	RTR 1,BLD 1,STA 6, CHORDWISE FORCE COEFFICI	
1717	RTR 1,BLD 1,STA 5, CHORDWISE FORCE COEFFICI	
1718	RTR 1,BLD 1,STA 4 CHORDWISE FORCE COEFFICI	
1719	RTR 1,BLD 1,STA 3 CHORDWISE FORCE COEFFICI	
1720	RTR 1,BLD 1,STA 2 CHORDWISE FORCE COEFFICI	
1721	RTR 1,BLD 1,STA 1 CHORDWISE FORCE COEFFICI	
1722	RTR 1,BLD 1,STA 0, CHORDWISE FORCE COEFFICI	
1723	RTR 1,BLD 1,STA 20, TOTAL PITCH MOMENT COEFF	
1724	RTR 1,BLD 1,STA 19, TOTAL PITCH MOMENT COEFF	
1725	RTR 1,BLD 1,STA 18, TOTAL PITCH MOMENT COEFF	
1726	RTR 1,BLD 1,STA 17, TOTAL PITCH MOMENT COEFF	
1727	RTR 1,BLD 1,STA 16, TOTAL PITCH MOMENT COEFF	
1728	RTR 1,BLD 1,STA 15, TOTAL PITCH MOMENT COEFF	
1729	RTR 1,BLD 1,STA 14, TOTAL PITCH MOMENT COEFF	
1730	RTR 1,BLD 1,STA 13, TOTAL PITCH MOMENT COEFF	
1731	RTR 1,BLD 1,STA 12, TOTAL PITCH MOMENT COEFF	
1732	RTR 1,BLD 1,STA 11, TOTAL PITCH MOMENT COEFF	
1733	RTR 1,BLD 1,STA 10, TOTAL PITCH MOMENT COEFF	
1734	RTR 1,BLD 1,STA 9, TOTAL PITCH MOMENT COEFF	
1735	RTR 1,BLD 1,STA 8, TOTAL PITCH MOMENT COEFF	
1736	RTR 1,BLD 1,STA 7, TOTAL PITCH MOMENT COEFF	
1737	RTR 1,BLD 1,STA 6, TOTAL PITCH MOMENT COEFF	
1738	RTR 1,BLD 1,STA 5, TOTAL PITCH MOMENT COEFF	
1739	RTR 1,BLD 1,STA 4 TOTAL PITCH MOMENT COEFF	
1740	RTR 1,BLD 1,STA 3 TOTAL PITCH MOMENT COEFF	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1741	RTR 1,BLD 1,STA 2 TOTAL PITCH MOMENT COEFF	
1742	RTR 1,BLD 1,STA 1 TOTAL PITCH MOMENT COEFF	
1743	RTR 1,BLD 1,STA 0. TOTAL PITCH MOMENT COEFF	
1744	RTR 1,BLD 1,STA 20. UNSTEADY PITCH MOMENT CO	
1745	RTR 1,BLD 1,STA 19. UNSTEADY PITCH MOMENT CO	
1746	RTR 1,BLD 1,STA 18. UNSTEADY PITCH MOMENT CO	
1747	RTR 1,BLD 1,STA 17. UNSTEADY PITCH MOMENT CO	
1748	RTR 1,BLD 1,STA 16. UNSTEADY PITCH MOMENT CO	
1749	RTR 1,BLD 1,STA 15. UNSTEADY PITCH MOMENT CO	
1750	RTR 1,BLD 1,STA 14. UNSTEADY PITCH MOMENT CO	
1751	RTR 1,BLD 1,STA 13. UNSTEADY PITCH MOMENT CO	
1752	RTR 1,BLD 1,STA 12. UNSTEADY PITCH MOMENT CO	
1753	RTR 1,BLD 1,STA 11. UNSTEADY PITCH MOMENT CO	
1754	RTR 1,BLD 1,STA 10. UNSTEADY PITCH MOMENT CO	
1755	RTR 1,BLD 1,STA 9. UNSTEADY PITCH MOMENT CO	
1756	RTR 1,BLD 1,STA 8. UNSTEADY PITCH MOMENT CO	
1757	RTR 1,BLD 1,STA 7. UNSTEADY PITCH MOMENT CO	
1758	RTR 1,BLD 1,STA 6. UNSTEADY PITCH MOMENT CO	
1759	RTR 1,BLD 1,STA 5. UNSTEADY PITCH MOMENT CO	
1760	RTR 1,BLD 1,STA 4 UNSTEADY PITCH MOMENT CO	
1761	RTR 1,BLD 1,STA 3 UNSTEADY PITCH MOMENT CO	
1762	RTR 1,BLD 1,STA 2 UNSTEADY PITCH MOMENT CO	
1763	RTR 1,BLD 1,STA 1 UNSTEADY PITCH MOMENT CO	
1764	RTR 1,BLD 1,STA 0. UNSTEADY PITCH MOMENT CO	
1765	RTR 1,BLD 1,STA 20. LIFT DISTRIBUTION	LBS/FT
1766	RTR 1,BLD 1,STA 19. LIFT DISTRIBUTION	LBS/FT
1767	RTR 1,BLD 1,STA 18. LIFT DISTRIBUTION	LBS/FT
1768	RTR 1,BLD 1,STA 17. LIFT DISTRIBUTION	LBS/FT
1769	RTR 1,BLD 1,STA 16. LIFT DISTRIBUTION	LBS/FT
1770	RTR 1,BLD 1,STA 15. LIFT DISTRIBUTION	LBS/FT
1771	RTR 1,BLD 1,STA 14. LIFT DISTRIBUTION	LBS/FT
1772	RTR 1,BLD 1,STA 13. LIFT DISTRIBUTION	LBS/FT
1773	RTR 1,BLD 1,STA 12. LIFT DISTRIBUTION	LBS/FT
1774	RTR 1,BLD 1,STA 11. LIFT DISTRIBUTION	LBS/FT
1775	RTR 1,BLD 1,STA 10. LIFT DISTRIBUTION	LBS/FT
1776	RTR 1,BLD 1,STA 9. LIFT DISTRIBUTION	LBS/FT
1777	RTR 1,BLD 1,STA 8. LIFT DISTRIBUTION	LBS/FT
1778	RTR 1,BLD 1,STA 7. LIFT DISTRIBUTION	LBS/FT
1779	RTR 1,BLD 1,STA 6. LIFT DISTRIBUTION	LBS/FT
1780	RTR 1,BLD 1,STA 5. LIFT DISTRIBUTION	LBS/FT
1781	RTR 1,BLD 1,STA 4 LIFT DISTRIBUTION	LBS/FT
1782	RTR 1,BLD 1,STA 3 LIFT DISTRIBUTION	LBS/FT
1783	RTR 1,BLD 1,STA 2 LIFT DISTRIBUTION	LBS/FT
1784	RTR 1,BLD 1,STA 1 LIFT DISTRIBUTION	LBS/FT
1785	RTR 1,BLD 1,STA 0. LIFT DISTRIBUTION	LBS/FT
1786	RTR 1,BLD 1,STA 20. DRAG DISTRIBUTION	LBS/FT
1787	RTR 1,BLD 1,STA 19. DRAG DISTRIBUTION	LBS/FT
1788	RTR 1,BLD 1,STA 18. DRAG DISTRIBUTION	LBS/FT
1789	RTR 1,BLD 1,STA 17. DRAG DISTRIBUTION	LBS/FT
1790	RTR 1,BLD 1,STA 16. DRAG DISTRIBUTION	LBS/FT
1791	RTR 1,BLD 1,STA 15. DRAG DISTRIBUTION	LBS/FT
1792	RTR 1,BLD 1,STA 14. DRAG DISTRIBUTION	LBS/FT
1793	RTR 1,BLD 1,STA 13. DRAG DISTRIBUTION	LBS/FT
1794	RTR 1,BLD 1,STA 12. DRAG DISTRIBUTION	LBS/FT
1795	RTR 1,BLD 1,STA 11. DRAG DISTRIBUTION	LBS/FT
1796	RTR 1,BLD 1,STA 10. DRAG DISTRIBUTION	LBS/FT
1797	RTR 1,BLD 1,STA 9. DRAG DISTRIBUTION	LBS/FT
1798	RTR 1,BLD 1,STA 8. DRAG DISTRIBUTION	LBS/FT
1799	RTR 1,BLD 1,STA 7. DRAG DISTRIBUTION	LBS/FT
1800	RTR 1,BLD 1,STA 6. DRAG DISTRIBUTION	LBS/FT

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1801	RTR 1,BLD 1,STA 5, DRAG DISTRIBUTION	LBS/FT
1802	RTR 1,BLD 1,STA 4 DRAG DISTRIBUTION	LBS/FT
1803	RTR 1,BLD 1,STA 3 DRAG DISTRIBUTION	LBS/FT
1804	RTR 1,BLD 1,STA 2 DRAG DISTRIBUTION	LBS/FT
1805	RTR 1,BLD 1,STA 1 DRAG DISTRIBUTION	LBS/FT
1806	RTR 1,BLD 1,STA 0, DRAG DISTRIBUTION	LBS/FT
1807	RTR 1,BLD 1,STA 20, PITCHING MOMENT	FT-LB/FT
1808	RTR 1,BLD 1,STA 19, PITCHING MOMENT	FT-LB/FT
1809	RTR 1,BLD 1,STA 18, PITCHING MOMENT	FT-LB/FT
1810	RTR 1,BLD 1,STA 17, PITCHING MOMENT	FT-LB/FT
1811	RTR 1,BLD 1,STA 16, PITCHING MOMENT	FT-LB/FT
1812	RTR 1,BLD 1,STA 15, PITCHING MOMENT	FT-LB/FT
1813	RTR 1,BLD 1,STA 14, PITCHING MOMENT	FT-LB/FT
1814	RTR 1,BLD 1,STA 13, PITCHING MOMENT	FT-LB/FT
1815	RTR 1,BLD 1,STA 12, PITCHING MOMENT	FT-LB/FT
1816	RTR 1,BLD 1,STA 11, PITCHING MOMENT	FT-LB/FT
1817	RTR 1,BLD 1,STA 10, PITCHING MOMENT	FT-LB/FT
1818	RTR 1,BLD 1,STA 9, PITCHING MOMENT	FT-LB/FT
1819	RTR 1,BLD 1,STA 8, PITCHING MOMENT	FT-LB/FT
1820	RTR 1,BLD 1,STA 7, PITCHING MOMENT	FT-LB/FT
1821	RTR 1,BLD 1,STA 6, PITCHING MOMENT	FT-LB/FT
1822	RTR 1,BLD 1,STA 5, PITCHING MOMENT	FT-LB/FT
1823	RTR 1,BLD 1,STA 4 PITCHING MOMENT	FT-LB/FT
1824	RTR 1,BLD 1,STA 3 PITCHING MOMENT	FT-LB/FT
1825	RTR 1,BLD 1,STA 2 PITCHING MOMENT	FT-LB/FT
1826	RTR 1,BLD 1,STA 1 PITCHING MOMENT	FT-LB/FT
1827	RTR 1,BLD 1,STA 0, PITCHING MOMENT	FT-LB/FT
1828	RTR 1,BLD 1,STA 20, TORQUE DISTRIBUTION	FT-LB/FT
1829	RTR 1,BLD 1,STA 19, TORQUE DISTRIBUTION	FT-LB/FT
1830	RTR 1,BLD 1,STA 18, TORQUE DISTRIBUTION	FT-LB/FT
1831	RTR 1,BLD 1,STA 17, TORQUE DISTRIBUTION	FT-LB/FT
1832	RTR 1,BLD 1,STA 16, TORQUE DISTRIBUTION	FT-LB/FT
1833	RTR 1,BLD 1,STA 15, TORQUE DISTRIBUTION	FT-LB/FT
1834	RTR 1,BLD 1,STA 14, TORQUE DISTRIBUTION	FT-LB/FT
1835	RTR 1,BLD 1,STA 13, TORQUE DISTRIBUTION	FT-LB/FT
1836	RTR 1,BLD 1,STA 12, TORQUE DISTRIBUTION	FT-LB/FT
1837	RTR 1,BLD 1,STA 11, TORQUE DISTRIBUTION	FT-LB/FT
1838	RTR 1,BLD 1,STA 10, TORQUE DISTRIBUTION	FT-LB/FT
1839	RTR 1,BLD 1,STA 9, TORQUE DISTRIBUTION	FT-LB/FT
1840	RTR 1,BLD 1,STA 8, TORQUE DISTRIBUTION	FT-LB/FT
1841	RTR 1,BLD 1,STA 7, TORQUE DISTRIBUTION	FT-LB/FT
1842	RTR 1,BLD 1,STA 6, TORQUE DISTRIBUTION	FT-LB/FT
1843	RTR 1,BLD 1,STA 5, TORQUE DISTRIBUTION	FT-LB/FT
1844	RTR 1,BLD 1,STA 4 TORQUE DISTRIBUTION	FT-LB/FT
1845	RTR 1,BLD 1,STA 3 TORQUE DISTRIBUTION	FT-LB/FT
1846	RTR 1,BLD 1,STA 2 TORQUE DISTRIBUTION	FT-LB/FT
1847	RTR 1,BLD 1,STA 1 TORQUE DISTRIBUTION	FT-LB/FT
1848	RTR 1,BLD 1,STA 0, TORQUE DISTRIBUTION	FT-LB/FT
1849	RTR 1,BLD 1,STA 20, INFLOW ANGLE	DEGREES
1850	RTR 1,BLD 1,STA 19, INFLOW ANGLE	DEGREES
1851	RTR 1,BLD 1,STA 18, INFLOW ANGLE	DEGREES
1852	RTR 1,BLD 1,STA 17, INFLOW ANGLE	DEGREES
1853	RTR 1,BLD 1,STA 16, INFLOW ANGLE	DEGREES
1854	RTR 1,BLD 1,STA 15, INFLOW ANGLE	DEGREES
1855	RTR 1,BLD 1,STA 14, INFLOW ANGLE	DEGREES
1856	RTR 1,BLD 1,STA 13, INFLOW ANGLE	DEGREES
1857	RTR 1,BLD 1,STA 12, INFLOW ANGLE	DEGREES
1858	RTR 1,BLD 1,STA 11, INFLOW ANGLE	DEGREES
1859	RTR 1,BLD 1,STA 10, INFLOW ANGLE	DEGREES
1860	RTR 1,BLD 1,STA 9, INFLOW ANGLE	DEGREES

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1861	RTR 1.BLD 1.STA 8. INFLOW ANGLE	DEGREES
1862	RTR 1.BLD 1.STA 7. INFLOW ANGLE	DEGREES
1863	RTR 1.BLD 1.STA 6. INFLOW ANGLE	DEGREES
1864	RTR 1.BLD 1.STA 5. INFLOW ANGLE	DEGREES
1865	RTR 1.BLD 1.STA 4 INFLOW ANGLE	DEGREES
1866	RTR 1.BLD 1.STA 3 INFLOW ANGLE	DEGREES
1867	RTR 1.BLD 1.STA 2 INFLOW ANGLE	DEGREES
1868	RTR 1.BLD 1.STA 1 INFLOW ANGLE	DEGREES
1869	RTR 1.BLD 1.STA 0. INFLOW ANGLE	DEGREES
1870	RTR 1.BLD 1.STA 20. GEOMETRIC PITCH ANGLE	DEGREES
1871	RTR 1.BLD 1.STA 19. GEOMETRIC PITCH ANGLE	DEGREES
1872	RTR 1.BLD 1.STA 18. GEOMETRIC PITCH ANGLE	DEGREES
1873	RTR 1.BLD 1.STA 17. GEOMETRIC PITCH ANGLE	DEGREES
1874	RTR 1.BLD 1.STA 16. GEOMETRIC PITCH ANGLE	DEGREES
1875	RTR 1.BLD 1.STA 15. GEOMETRIC PITCH ANGLE	DEGREES
1876	RTR 1.BLD 1.STA 14. GEOMETRIC PITCH ANGLE	DEGREES
1877	RTR 1.BLD 1.STA 13. GEOMETRIC PITCH ANGLE	DEGREES
1878	RTR 1.BLD 1.STA 12. GEOMETRIC PITCH ANGLE	DEGREES
1879	RTR 1.BLD 1.STA 11. GEOMETRIC PITCH ANGLE	DEGREES
1880	RTR 1.BLD 1.STA 10. GEOMETRIC PITCH ANGLE	DEGREES
1881	RTR 1.BLD 1.STA 9. GEOMETRIC PITCH ANGLE	DEGREES
1882	RTR 1.BLD 1.STA 8. GEOMETRIC PITCH ANGLE	DEGREES
1883	RTR 1.BLD 1.STA 7. GEOMETRIC PITCH ANGLE	DEGREES
1884	RTR 1.BLD 1.STA 6. GEOMETRIC PITCH ANGLE	DEGREES
1885	RTR 1.BLD 1.STA 5. GEOMETRIC PITCH ANGLE	DEGREES
1886	RTR 1.BLD 1.STA 4 GEOMETRIC PITCH ANGLE	DEGREES
1887	RTR 1.BLD 1.STA 3 GEOMETRIC PITCH ANGLE	DEGREES
1888	RTR 1.BLD 1.STA 2 GEOMETRIC PITCH ANGLE	DEGREES
1889	RTR 1.BLD 1.STA 1 GEOMETRIC PITCH ANGLE	DEGREES
1890	RTR 1.BLD 1.STA 0. GEOMETRIC PITCH ANGLE	DEGREES
1891	RTR 1.BLD 1.STA 20. LOCAL INDUCED VELOCITY	FT/SEC
1892	RTR 1.BLD 1.STA 19. LOCAL INDUCED VELOCITY	FT/SEC
1893	RTR 1.BLD 1.STA 18. LOCAL INDUCED VELOCITY	FT/SEC
1894	RTR 1.BLD 1.STA 17. LOCAL INDUCED VELOCITY	FT/SEC
1895	RTR 1.BLD 1.STA 16. LOCAL INDUCED VELOCITY	FT/SEC
1896	RTR 1.BLD 1.STA 15. LOCAL INDUCED VELOCITY	FT/SEC
1897	RTR 1.BLD 1.STA 14. LOCAL INDUCED VELOCITY	FT/SEC
1898	RTR 1.BLD 1.STA 13. LOCAL INDUCED VELOCITY	FT/SEC
1899	RTR 1.BLD 1.STA 12. LOCAL INDUCED VELOCITY	FT/SEC
1900	RTR 1.BLD 1.STA 11. LOCAL INDUCED VELOCITY	FT/SEC
1901	RTR 1.BLD 1.STA 10. LOCAL INDUCED VELOCITY	FT/SEC
1902	RTR 1.BLD 1.STA 9. LOCAL INDUCED VELOCITY	FT/SEC
1903	RTR 1.BLD 1.STA 8. LOCAL INDUCED VELOCITY	FT/SEC
1904	RTR 1.BLD 1.STA 7. LOCAL INDUCED VELOCITY	FT/SEC
1905	RTR 1.BLD 1.STA 6. LOCAL INDUCED VELOCITY	FT/SEC
1906	RTR 1.BLD 1.STA 5. LOCAL INDUCED VELOCITY	FT/SEC
1907	RTR 1.BLD 1.STA 4 LOCAL INDUCED VELOCITY	FT/SEC
1908	RTR 1.BLD 1.STA 3 LOCAL INDUCED VELOCITY	FT/SEC
1909	RTR 1.BLD 1.STA 2 LOCAL INDUCED VELOCITY	FT/SEC
1910	RTR 1.BLD 1.STA 1 LOCAL INDUCED VELOCITY	FT/SEC
1911	RTR 1.BLD 1.STA 0. LOCAL INDUCED VELOCITY	FT/SEC
1912	RTR 1.BLD 1.STA 20. LOCAL INFLOW VELOCITY	FT/SEC
1913	RTR 1.BLD 1.STA 19. LOCAL INFLOW VELOCITY	FT/SEC
1914	RTR 1.BLD 1.STA 18. LOCAL INFLOW VELOCITY	FT/SEC
1915	RTR 1.BLD 1.STA 17. LOCAL INFLOW VELOCITY	FT/SEC
1916	RTR 1.BLD 1.STA 16. LOCAL INFLOW VELOCITY	FT/SEC
1917	RTR 1.BLD 1.STA 15. LOCAL INFLOW VELOCITY	FT/SEC
1918	RTR 1.BLD 1.STA 14. LOCAL INFLOW VELOCITY	FT/SEC
1919	RTR 1.BLD 1.STA 13. LOCAL INFLOW VELOCITY	FT/SEC
1920	RTR 1.BLD 1.STA 12. LOCAL INFLOW VELOCITY	FT/SEC

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1921	RTR 1,BLD 1,STA 11. LOCAL INFLOW VELOCITY	FT/SEC
1922	RTR 1,BLD 1,STA 10. LOCAL INFLOW VELOCITY	FT/SEC
1923	RTR 1,BLD 1,STA 9. LOCAL INFLOW VELOCITY	FT/SEC
1924	RTR 1,BLD 1,STA 8. LOCAL INFLOW VELOCITY	FT/SEC
1925	RTR 1,BLD 1,STA 7. LOCAL INFLOW VELOCITY	FT/SEC
1926	RTR 1,BLD 1,STA 6. LOCAL INFLOW VELOCITY	FT/SEC
1927	RTR 1,BLD 1,STA 5. LOCAL INFLOW VELOCITY	FT/SEC
1928	RTR 1,BLD 1,STA 4 LOCAL INFLOW VELOCITY	FT/SEC
1929	RTR 1,BLD 1,STA 3 LOCAL INFLOW VELOCITY	FT/SEC
1930	RTR 1,BLD 1,STA 2 LOCAL INFLOW VELOCITY	FT/SEC
1931	RTR 1,BLD 1,STA 1 LOCAL INFLOW VELOCITY	FT/SEC
1932	RTR 1,BLD 1,STA 0. LOCAL INFLOW VELOCITY	FT/SEC
1933	RTR 1,BLD 1,STA 20. LOCAL TANGENTIAL VELOCIT	FT/SEC
1934	RTR 1,BLD 1,STA 19. LOCAL TANGENTIAL VELOCIT	FT/SEC
1935	RTR 1,BLD 1,STA 18. LOCAL TANGENTIAL VELOCIT	FT/SEC
1936	RTR 1,BLD 1,STA 17. LOCAL TANGENTIAL VELOCIT	FT/SEC
1937	RTR 1,BLD 1,STA 16. LOCAL TANGENTIAL VELOCIT	FT/SEC
1938	RTR 1,BLD 1,STA 15. LOCAL TANGENTIAL VELOCIT	FT/SEC
1939	RTR 1,BLD 1,STA 14. LOCAL TANGENTIAL VELOCIT	FT/SEC
1940	RTR 1,BLD 1,STA 13. LOCAL TANGENTIAL VELOCIT	FT/SEC
1941	RTR 1,BLD 1,STA 12. LOCAL TANGENTIAL VELOCIT	FT/SEC
1942	RTR 1,BLD 1,STA 11. LOCAL TANGENTIAL VELOCIT	FT/SEC
1943	RTR 1,BLD 1,STA 10. LOCAL TANGENTIAL VELOCIT	FT/SEC
1944	RTR 1,BLD 1,STA 9. LOCAL TANGENTIAL VELOCIT	FT/SEC
1945	RTR 1,BLD 1,STA 8. LOCAL TANGENTIAL VELOCIT	FT/SEC
1946	RTR 1,BLD 1,STA 7. LOCAL TANGENTIAL VELOCIT	FT/SEC
1947	RTR 1,BLD 1,STA 6. LOCAL TANGENTIAL VELOCIT	FT/SEC
1948	RTR 1,BLD 1,STA 5. LOCAL TANGENTIAL VELOCIT	FT/SEC
1949	RTR 1,BLD 1,STA 4 LOCAL TANGENTIAL VELOCIT	FT/SEC
1950	RTR 1,BLD 1,STA 3 LOCAL TANGENTIAL VELOCIT	FT/SEC
1951	RTR 1,BLD 1,STA 2 LOCAL TANGENTIAL VELOCIT	FT/SEC
1952	RTR 1,BLD 1,STA 1 LOCAL TANGENTIAL VELOCIT	FT/SEC
1953	RTR 1,BLD 1,STA 0. LOCAL TANGENTIAL VELOCIT	FT/SEC
1954	RTR 1,BLD 1,STA 20. LOCAL RADIAL VELOCITY	FT/SEC
1955	RTR 1,BLD 1,STA 19. LOCAL RADIAL VELOCITY	FT/SEC
1956	RTR 1,BLD 1,STA 18. LOCAL RADIAL VELOCITY	FT/SEC
1957	RTR 1,BLD 1,STA 17. LOCAL RADIAL VELOCITY	FT/SEC
1958	RTR 1,BLD 1,STA 16. LOCAL RADIAL VELOCITY	FT/SEC
1959	RTR 1,BLD 1,STA 15. LOCAL RADIAL VELOCITY	FT/SEC
1960	RTR 1,BLD 1,STA 14. LOCAL RADIAL VELOCITY	FT/SEC
1961	RTR 1,BLD 1,STA 13. LOCAL RADIAL VELOCITY	FT/SEC
1962	RTR 1,BLD 1,STA 12. LOCAL RADIAL VELOCITY	FT/SEC
1963	RTR 1,BLD 1,STA 11. LOCAL RADIAL VELOCITY	FT/SEC
1964	RTR 1,BLD 1,STA 10. LOCAL RADIAL VELOCITY	FT/SEC
1965	RTR 1,BLD 1,STA 9. LOCAL RADIAL VELOCITY	FT/SEC
1966	RTR 1,BLD 1,STA 8. LOCAL RADIAL VELOCITY	FT/SEC
1967	RTR 1,BLD 1,STA 7. LOCAL RADIAL VELOCITY	FT/SEC
1968	RTR 1,BLD 1,STA 6. LOCAL RADIAL VELOCITY	FT/SEC
1969	RTR 1,BLD 1,STA 5. LOCAL RADIAL VELOCITY	FT/SEC
1970	RTR 1,BLD 1,STA 4 LOCAL RADIAL VELOCITY	FT/SEC
1971	RTR 1,BLD 1,STA 3 LOCAL RADIAL VELOCITY	FT/SEC
1972	RTR 1,BLD 1,STA 2 LOCAL RADIAL VELOCITY	FT/SEC
1973	RTR 1,BLD 1,STA 1 LOCAL RADIAL VELOCITY	FT/SEC
1974	RTR 1,BLD 1,STA 0. LOCAL RADIAL VELOCITY	FT/SEC
1975	RTR 1,BLD 1,STA 20. YAWED FLOW ANGLE	DEGREES
1976	RTR 1,BLD 1,STA 19. YAWED FLOW ANGLE	DEGREES
1977	RTR 1,BLD 1,STA 18. YAWED FLOW ANGLE	DEGREES
1978	RTR 1,BLD 1,STA 17. YAWED FLOW ANGLE	DEGREES
1979	RTR 1,BLD 1,STA 16. YAWED FLOW ANGLE	DEGREES
1980	RTR 1,BLD 1,STA 15. YAWED FLOW ANGLE	DEGREES

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
1981	RTR 1,BLD 1,STA 14, YAWED FLOW ANGLE	DEGREES
1982	RTR 1,BLD 1,STA 13, YAWED FLOW ANGLE	DEGREES
1983	RTR 1,BLD 1,STA 12, YAWED FLOW ANGLE	DEGREES
1984	RTR 1,BLD 1,STA 11, YAWED FLOW ANGLE	DEGREES
1985	RTR 1,BLD 1,STA 10, YAWED FLOW ANGLE	DEGREES
1986	RTR 1,BLD 1,STA 9, YAWED FLOW ANGLE	DEGREES
1987	RTR 1,BLD 1,STA 8, YAWED FLOW ANGLE	DEGREES
1988	RTR 1,BLD 1,STA 7, YAWED FLOW ANGLE	DEGREES
1989	RTR 1,BLD 1,STA 6, YAWED FLOW ANGLE	DEGREES
1990	RTR 1,BLD 1,STA 5, YAWED FLOW ANGLE	DEGREES
1991	RTR 1,BLD 1,STA 4 YAWED FLOW ANGLE	DEGREES
1992	RTR 1,BLD 1,STA 3 YAWED FLOW ANGLE	DEGREES
1993	RTR 1,BLD 1,STA 2 YAWED FLOW ANGLE	DEGREES
1994	RTR 1,BLD 1,STA 1 YAWED FLOW ANGLE	DEGREES
1995	RTR 1,BLD 1,STA 0, YAWED FLOW ANGLE	DEGREES
1996	RTR 1,BLD 1,STA 20, OUT OF PLANE DEFLECTION	FEET
1997	RTR 1,BLD 1,STA 19, OUT OF PLANE DEFLECTION	FEET
1998	RTR 1,BLD 1,STA 18, OUT OF PLANE DEFLECTION	FEET
1999	RTR 1,BLD 1,STA 17, OUT OF PLANE DEFLECTION	FEET
2000	RTR 1,BLD 1,STA 16, OUT OF PLANE DEFLECTION	FEET
2001	RTR 1,BLD 1,STA 15, OUT OF PLANE DEFLECTION	FEET
2002	RTR 1,BLD 1,STA 14, OUT OF PLANE DEFLECTION	FEET
2003	RTR 1,BLD 1,STA 13, OUT OF PLANE DEFLECTION	FEET
2004	RTR 1,BLD 1,STA 12, OUT OF PLANE DEFLECTION	FEET
2005	RTR 1,BLD 1,STA 11, OUT OF PLANE DEFLECTION	FEET
2006	RTR 1,BLD 1,STA 10, OUT OF PLANE DEFLECTION	FEET
2007	RTR 1,BLD 1,STA 9, OUT OF PLANE DEFLECTION	FEET
2008	RTR 1,BLD 1,STA 8, OUT OF PLANE DEFLECTION	FEET
2009	RTR 1,BLD 1,STA 7, OUT OF PLANE DEFLECTION	FEET
2010	RTR 1,BLD 1,STA 6, OUT OF PLANE DEFLECTION	FEET
2011	RTR 1,BLD 1,STA 5, OUT OF PLANE DEFLECTION	FEET
2012	RTR 1,BLD 1,STA 4 OUT OF PLANE DEFLECTION	FEET
2013	RTR 1,BLD 1,STA 3 OUT OF PLANE DEFLECTION	FEET
2014	RTR 1,BLD 1,STA 2 OUT OF PLANE DEFLECTION	FEET
2015	RTR 1,BLD 1,STA 1 OUT OF PLANE DEFLECTION	FEET
2016	RTR 1,BLD 1,STA 0, OUT OF PLANE DEFLECTION	FEET
2017	RTR 1,BLD 1,STA 20, IN PLANE DEFLECTION	FEET
2018	RTR 1,BLD 1,STA 19, IN PLANE DEFLECTION	FEET
2019	RTR 1,BLD 1,STA 18, IN PLANE DEFLECTION	FEET
2020	RTR 1,BLD 1,STA 17, IN PLANE DEFLECTION	FEET
2021	RTR 1,BLD 1,STA 16, IN PLANE DEFLECTION	FEET
2022	RTR 1,BLD 1,STA 15, IN PLANE DEFLECTION	FEET
2023	RTR 1,BLD 1,STA 14, IN PLANE DEFLECTION	FEET
2024	RTR 1,BLD 1,STA 13, IN PLANE DEFLECTION	FEET
2025	RTR 1,BLD 1,STA 12, IN PLANE DEFLECTION	FEET
2026	RTR 1,BLD 1,STA 11, IN PLANE DEFLECTION	FEET
2027	RTR 1,BLD 1,STA 10, IN PLANE DEFLECTION	FEET
2028	RTR 1,BLD 1,STA 9, IN PLANE DEFLECTION	FEET
2029	RTR 1,BLD 1,STA 8, IN PLANE DEFLECTION	FEET
2030	RTR 1,BLD 1,STA 7, IN PLANE DEFLECTION	FEET
2031	RTR 1,BLD 1,STA 6, IN PLANE DEFLECTION	FEET
2032	RTR 1,BLD 1,STA 5, IN PLANE DEFLECTION	FEET
2033	RTR 1,BLD 1,STA 4 IN PLANE DEFLECTION	FEET
2034	RTR 1,BLD 1,STA 3 IN PLANE DEFLECTION	FEET
2035	RTR 1,BLD 1,STA 2 IN PLANE DEFLECTION	FEET
2036	RTR 1,BLD 1,STA 1 IN PLANE DEFLECTION	FEET
2037	RTR 1,BLD 1,STA 0, IN PLANE DEFLECTION	FEET
2038	RTR 1,BLD 1,STA 20, TORSIONAL DEFLECTION	DEGREES
2039	RTR 1,BLD 1,STA 19, TORSIONAL DEFLECTION	DEGREES
2040	RTR 1,BLD 1,STA 18, TORSIONAL DEFLECTION	DEGREES

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2041	RTR 1,BLD 1,STA 17. TORSIONAL DEFLECTION	DEGREES
2042	RTR 1,BLD 1,STA 16. TORSIONAL DEFLECTION	DEGREES
2043	RTR 1,BLD 1,STA 15. TORSIONAL DEFLECTION	DEGREES
2044	RTR 1,BLD 1,STA 14. TORSIONAL DEFLECTION	DEGREES
2045	RTR 1,BLD 1,STA 13. TORSIONAL DEFLECTION	DEGREES
2046	RTR 1,BLD 1,STA 12. TORSIONAL DEFLECTION	DEGREES
2047	RTR 1,BLD 1,STA 11. TORSIONAL DEFLECTION	DEGREES
2048	RTR 1,BLD 1,STA 10. TORSIONAL DEFLECTION	DEGREES
2049	RTR 1,BLD 1,STA 9. TORSIONAL DEFLECTION	DEGREES
2050	RTR 1,BLD 1,STA 8. TORSIONAL DEFLECTION	DEGREES
2051	RTR 1,BLD 1,STA 7. TORSIONAL DEFLECTION	DEGREES
2052	RTR 1,BLD 1,STA 6. TORSIONAL DEFLECTION	DEGREES
2053	RTR 1,BLD 1,STA 5. TORSIONAL DEFLECTION	DEGREES
2054	RTR 1,BLD 1,STA 4 TORSIONAL DEFLECTION	DEGREES
2055	RTR 1,BLD 1,STA 3 TORSIONAL DEFLECTION	DEGREES
2056	RTR 1,BLD 1,STA 2 TORSIONAL DEFLECTION	DEGREES
2057	RTR 1,BLD 1,STA 1 TORSIONAL DEFLECTION	DEGREES
2058	RTR 1,BLD 1,STA 0. TORSIONAL DEFLECTION	DEGREES
2059	NOT USED	
2060	NOT USED	
2061	NOT USED	
2062	NOT USED	
2063	NOT USED	
2064	NOT USED	
2065	NOT USED	
2066	NOT USED	
2067	NOT USED	
2068	NOT USED	
2069	NOT USED	
2070	NOT USED	
2071	NOT USED	
2072	NOT USED	
2073	NOT USED	
2074	NOT USED	
2075	NOT USED	
2076	NOT USED	
2077	NOT USED	
2078	NOT USED	
2079	NOT USED	
2080	NOT USED	
2081	NOT USED	
2082	NOT USED	
2083	NOT USED	
2084	NOT USED	
2085	NOT USED	
2086	NOT USED	
2087	NOT USED	
2088	NOT USED	
2089	NOT USED	
2090	NOT USED	
2091	NOT USED	
2092	NOT USED	
2093	NOT USED	
2094	NOT USED	
2095	NOT USED	
2096	NOT USED	
2097	NOT USED	
2098	NOT USED	
2099	NOT USED	
2100	NOT USED	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2101	RTR 2,BLD 1,STA 20, MACH NUMBER	
2102	RTR 2,BLD 1,STA 19, MACH NUMBER	
2103	RTR 2,BLD 1,STA 18, MACH NUMBER	
2104	RTR 2,BLD 1,STA 17, MACH NUMBER	
2105	RTR 2,BLD 1,STA 16, MACH NUMBER	
2106	RTR 2,BLD 1,STA 15, MACH NUMBER	
2107	RTR 2,BLD 1,STA 14, MACH NUMBER	
2108	RTR 2,BLD 1,STA 13, MACH NUMBER	
2109	RTR 2,BLD 1,STA 12, MACH NUMBER	
2110	RTR 2,BLD 1,STA 11, MACH NUMBER	
2111	RTR 2,BLD 1,STA 10, MACH NUMBER	
2112	RTR 2,BLD 1,STA 9, MACH NUMBER	
2113	RTR 2,BLD 1,STA 8, MACH NUMBER	
2114	RTR 2,BLD 1,STA 7, MACH NUMBER	
2115	RTR 2,BLD 1,STA 6, MACH NUMBER	
2116	RTR 2,BLD 1,STA 5, MACH NUMBER	
2117	RTR 2,BLD 1,STA 4 MACH NUMBER	
2118	RTR 2,BLD 1,STA 3 MACH NUMBER	
2119	RTR 2,BLD 1,STA 2 MACH NUMBER	
2120	RTR 2,BLD 1,STA 1 MACH NUMBER	
2121	RTR 2,BLD 1,STA 0, MACH NUMBER	
2122	RTR 2,BLD 1,STA 20, ANGLE OF ATTACK	DEGREES
2123	RTR 2,BLD 1,STA 19, ANGLE OF ATTACK	DEGREES
2124	RTR 2,BLD 1,STA 18, ANGLE OF ATTACK	DEGREES
2125	RTR 2,BLD 1,STA 17, ANGLE OF ATTACK	DEGREES
2126	RTR 2,BLD 1,STA 16, ANGLE OF ATTACK	DEGREES
2127	RTR 2,BLD 1,STA 15, ANGLE OF ATTACK	DEGREES
2128	RTR 2,BLD 1,STA 14, ANGLE OF ATTACK	DEGREES
2129	RTR 2,BLD 1,STA 13, ANGLE OF ATTACK	DEGREES
2130	RTR 2,BLD 1,STA 12, ANGLE OF ATTACK	DEGREES
2131	RTR 2,BLD 1,STA 11, ANGLE OF ATTACK	DEGREES
2132	RTR 2,BLD 1,STA 10, ANGLE OF ATTACK	DEGREES
2133	RTR 2,BLD 1,STA 9, ANGLE OF ATTACK	DEGREES
2134	RTR 2,BLD 1,STA 8, ANGLE OF ATTACK	DEGREES
2135	RTR 2,BLD 1,STA 7, ANGLE OF ATTACK	DEGREES
2136	RTR 2,BLD 1,STA 6, ANGLE OF ATTACK	DEGREES
2137	RTR 2,BLD 1,STA 5, ANGLE OF ATTACK	DEGREES
2138	RTR 2,BLD 1,STA 4 ANGLE OF ATTACK	DEGREES
2139	RTR 2,BLD 1,STA 3 ANGLE OF ATTACK	DEGREES
2140	RTR 2,BLD 1,STA 2 ANGLE OF ATTACK	DEGREES
2141	RTR 2,BLD 1,STA 1 ANGLE OF ATTACK	DEGREES
2142	RTR 2,BLD 1,STA 0, ANGLE OF ATTACK	DEGREES
2143	RTR 2,BLD 1,STA 20, TOTAL LIFT COEFFICIENT	
2144	RTR 2,BLD 1,STA 19, TOTAL LIFT COEFFICIENT	
2145	RTR 2,BLD 1,STA 18, TOTAL LIFT COEFFICIENT	
2146	RTR 2,BLD 1,STA 17, TOTAL LIFT COEFFICIENT	
2147	RTR 2,BLD 1,STA 16, TOTAL LIFT COEFFICIENT	
2148	RTR 2,BLD 1,STA 15, TOTAL LIFT COEFFICIENT	
2149	RTR 2,BLD 1,STA 14, TOTAL LIFT COEFFICIENT	
2150	RTR 2,BLD 1,STA 13, TOTAL LIFT COEFFICIENT	
2151	RTR 2,BLD 1,STA 12, TOTAL LIFT COEFFICIENT	
2152	RTR 2,BLD 1,STA 11, TOTAL LIFT COEFFICIENT	
2153	RTR 2,BLD 1,STA 10, TOTAL LIFT COEFFICIENT	
2154	RTR 2,BLD 1,STA 9, TOTAL LIFT COEFFICIENT	
2155	RTR 2,BLD 1,STA 8, TOTAL LIFT COEFFICIENT	
2156	RTR 2,BLD 1,STA 7, TOTAL LIFT COEFFICIENT	
2157	RTR 2,BLD 1,STA 6, TOTAL LIFT COEFFICIENT	
2158	RTR 2,BLD 1,STA 5, TOTAL LIFT COEFFICIENT	
2159	RTR 2,BLD 1,STA 4 TOTAL LIFT COEFFICIENT	
2160	RTR 2,BLD 1,STA 3 TOTAL LIFT COEFFICIENT	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2161	RTR 2,BLD 1,STA 2 TOTAL LIFT COEFFICIENT	
2162	RTR 2,BLD 1,STA 1 TOTAL LIFT COEFFICIENT	
2163	RTR 2,BLD 1,STA 0. TOTAL LIFT COEFFICIENT	
2164	RTR 2,BLD 1,STA 20. UNSTEADY LIFT COEFFICIEN	
2165	RTR 2,BLD 1,STA 19. UNSTEADY LIFT COEFFICIEN	
2166	RTR 2,BLD 1,STA 18. UNSTEADY LIFT COEFFICIEN	
2167	RTR 2,BLD 1,STA 17. UNSTEADY LIFT COEFFICIEN	
2168	RTR 2,BLD 1,STA 16. UNSTEADY LIFT COEFFICIEN	
2169	RTR 2,BLD 1,STA 15. UNSTEADY LIFT COEFFICIEN	
2170	RTR 2,BLD 1,STA 14. UNSTEADY LIFT COEFFICIEN	
2171	RTR 2,BLD 1,STA 13. UNSTEADY LIFT COEFFICIEN	
2172	RTR 2,BLD 1,STA 12. UNSTEADY LIFT COEFFICIEN	
2173	RTR 2,BLD 1,STA 11. UNSTEADY LIFT COEFFICIEN	
2174	RTR 2,BLD 1,STA 10. UNSTEADY LIFT COEFFICIEN	
2175	RTR 2,BLD 1,STA 9. UNSTEADY LIFT COEFFICIEN	
2176	RTR 2,BLD 1,STA 8. UNSTEADY LIFT COEFFICIEN	
2177	RTR 2,BLD 1,STA 7. UNSTEADY LIFT COEFFICIEN	
2178	RTR 2,BLD 1,STA 6. UNSTEADY LIFT COEFFICIEN	
2179	RTR 2,BLD 1,STA 5. UNSTEADY LIFT COEFFICIEN	
2180	RTR 2,BLD 1,STA 4 UNSTEADY LIFT COEFFICIEN	
2181	RTR 2,BLD 1,STA 3 UNSTEADY LIFT COEFFICIEN	
2182	RTR 2,BLD 1,STA 2 UNSTEADY LIFT COEFFICIEN	
2183	RTR 2,BLD 1,STA 1 UNSTEADY LIFT COEFFICIEN	
2184	RTR 2,BLD 1,STA 0. UNSTEADY LIFT COEFFICIEN	
2185	RTR 2,BLD 1,STA 20. NORMAL FORCE COEFFICIENT	
2186	RTR 2,BLD 1,STA 19. NORMAL FORCE COEFFICIENT	
2187	RTR 2,BLD 1,STA 18. NORMAL FORCE COEFFICIENT	
2188	RTR 2,BLD 1,STA 17. NORMAL FORCE COEFFICIENT	
2189	RTR 2,BLD 1,STA 16. NORMAL FORCE COEFFICIENT	
2190	RTR 2,BLD 1,STA 15. NORMAL FORCE COEFFICIENT	
2191	RTR 2,BLD 1,STA 14. NORMAL FORCE COEFFICIENT	
2192	RTR 2,BLD 1,STA 13. NORMAL FORCE COEFFICIENT	
2193	RTR 2,BLD 1,STA 12. NORMAL FORCE COEFFICIENT	
2194	RTR 2,BLD 1,STA 11. NORMAL FORCE COEFFICIENT	
2195	RTR 2,BLD 1,STA 10. NORMAL FORCE COEFFICIENT	
2196	RTR 2,BLD 1,STA 9. NORMAL FORCE COEFFICIENT	
2197	RTR 2,BLD 1,STA 8. NORMAL FORCE COEFFICIENT	
2198	RTR 2,BLD 1,STA 7. NORMAL FORCE COEFFICIENT	
2199	RTR 2,BLD 1,STA 6. NORMAL FORCE COEFFICIENT	
2200	RTR 2,BLD 1,STA 5. NORMAL FORCE COEFFICIENT	
2201	RTR 2,BLD 1,STA 4 NORMAL FORCE COEFFICIENT	
2202	RTR 2,BLD 1,STA 3 NORMAL FORCE COEFFICIENT	
2203	RTR 2,BLD 1,STA 2 NORMAL FORCE COEFFICIENT	
2204	RTR 2,BLD 1,STA 1 NORMAL FORCE COEFFICIENT	
2205	RTR 2,BLD 1,STA 0. NORMAL FORCE COEFFICIENT	
2206	RTR 2,BLD 1,STA 20. DRAG COEFFICIENT	
2207	RTR 2,BLD 1,STA 19. DRAG COEFFICIENT	
2208	RTR 2,BLD 1,STA 18. DRAG COEFFICIENT	
2209	RTR 2,BLD 1,STA 17. DRAG COEFFICIENT	
2210	RTR 2,BLD 1,STA 16. DRAG COEFFICIENT	
2211	RTR 2,BLD 1,STA 15. DRAG COEFFICIENT	
2212	RTR 2,BLD 1,STA 14. DRAG COEFFICIENT	
2213	RTR 2,BLD 1,STA 13. DRAG COEFFICIENT	
2214	RTR 2,BLD 1,STA 12. DRAG COEFFICIENT	
2215	RTR 2,BLD 1,STA 11. DRAG COEFFICIENT	
2216	RTR 2,BLD 1,STA 10. DRAG COEFFICIENT	
2217	RTR 2,BLD 1,STA 9. DRAG COEFFICIENT	
2218	RTR 2,BLD 1,STA 8. DRAG COEFFICIENT	
2219	RTR 2,BLD 1,STA 7. DRAG COEFFICIENT	
2220	RTR 2,BLD 1,STA 6. DRAG COEFFICIENT	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2221	RTR 2,BLD 1,STA 5, DRAG COEFFICIENT	
2222	RTR 2,BLD 1,STA 4 DRAG COEFFICIENT	
2223	RTR 2,BLD 1,STA 3 DRAG COEFFICIENT	
2224	RTR 2,BLD 1,STA 2 DRAG COEFFICIENT	
2225	RTR 2,BLD 1,STA 1 DRAG COEFFICIENT	
2226	RTR 2,BLD 1,STA 0, DRAG COEFFICIENT	
2227	RTR 2,BLD 1,STA 20, CHORDWISE FORCE COEFFICI	
2228	RTR 2,BLD 1,STA 19, CHORDWISE FORCE COEFFICI	
2229	RTR 2,BLD 1,STA 18, CHORDWISE FORCE COEFFICI	
2230	RTR 2,BLD 1,STA 17, CHORDWISE FORCE COEFFICI	
2231	RTR 2,BLD 1,STA 16, CHORDWISE FORCE COEFFICI	
2232	RTR 2,BLD 1,STA 15, CHORDWISE FORCE COEFFICI	
2233	RTR 2,BLD 1,STA 14, CHORDWISE FORCE COEFFICI	
2234	RTR 2,BLD 1,STA 13, CHORDWISE FORCE COEFFICI	
2235	RTR 2,BLD 1,STA 12, CHORDWISE FORCE COEFFICI	
2236	RTR 2,BLD 1,STA 11, CHORDWISE FORCE COEFFICI	
2237	RTR 2,BLD 1,STA 10, CHORDWISE FORCE COEFFICI	
2238	RTR 2,BLD 1,STA 9, CHORDWISE FORCE COEFFICI	
2239	RTR 2,BLD 1,STA 8, CHORDWISE FORCE COEFFICI	
2240	RTR 2,BLD 1,STA 7, CHORDWISE FORCE COEFFICI	
2241	RTR 2,BLD 1,STA 6, CHORDWISE FORCE COEFFICI	
2242	RTR 2,BLD 1,STA 5, CHORDWISE FORCE COEFFICI	
2243	RTR 2,BLD 1,STA 4 CHORDWISE FORCE COEFFICI	
2244	RTR 2,BLD 1,STA 3 CHORDWISE FORCE COEFFICI	
2245	RTR 2,BLD 1,STA 2 CHORDWISE FORCE COEFFICI	
2246	RTR 2,BLD 1,STA 1 CHORDWISE FORCE COEFFICI	
2247	RTR 2,BLD 1,STA 0, CHORDWISE FORCE COEFFICI	
2248	RTR 2,BLD 1,STA 20, TOTAL PITCH MOMENT COEFF	
2249	RTR 2,BLD 1,STA 19, TOTAL PITCH MOMENT COEFF	
2250	RTR 2,BLD 1,STA 18, TOTAL PITCH MOMENT COEFF	
2251	RTR 2,BLD 1,STA 17, TOTAL PITCH MOMENT COEFF	
2252	RTR 2,BLD 1,STA 16, TOTAL PITCH MOMENT COEFF	
2253	RTR 2,BLD 1,STA 15, TOTAL PITCH MOMENT COEFF	
2254	RTR 2,BLD 1,STA 14, TOTAL PITCH MOMENT COEFF	
2255	RTR 2,BLD 1,STA 13, TOTAL PITCH MOMENT COEFF	
2256	RTR 2,BLD 1,STA 12, TOTAL PITCH MOMENT COEFF	
2257	RTR 2,BLD 1,STA 11, TOTAL PITCH MOMENT COEFF	
2258	RTR 2,BLD 1,STA 10, TOTAL PITCH MOMENT COEFF	
2259	RTR 2,BLD 1,STA 9, TOTAL PITCH MOMENT COEFF	
2260	RTR 2,BLD 1,STA 8, TOTAL PITCH MOMENT COEFF	
2261	RTR 2,BLD 1,STA 7, TOTAL PITCH MOMENT COEFF	
2262	RTR 2,BLD 1,STA 6, TOTAL PITCH MOMENT COEFF	
2263	RTR 2,BLD 1,STA 5, TOTAL PITCH MOMENT COEFF	
2264	RTR 2,BLD 1,STA 4 TOTAL PITCH MOMENT COEFF	
2265	RTR 2,BLD 1,STA 3 TOTAL PITCH MOMENT COEFF	
2266	RTR 2,BLD 1,STA 2 TOTAL PITCH MOMENT COEFF	
2267	RTR 2,BLD 1,STA 1 TOTAL PITCH MOMENT COEFF	
2268	RTR 2,BLD 1,STA 0, TOTAL PITCH MOMENT COEFF	
2269	RTR 2,BLD 1,STA 20, UNSTEADY PITCH MOMENT CO	
2270	RTR 2,BLD 1,STA 19, UNSTEADY PITCH MOMENT CO	
2271	RTR 2,BLD 1,STA 18, UNSTEADY PITCH MOMENT CO	
2272	RTR 2,BLD 1,STA 17, UNSTEADY PITCH MOMENT CO	
2273	RTR 2,BLD 1,STA 16, UNSTEADY PITCH MOMENT CO	
2274	RTR 2,BLD 1,STA 15, UNSTEADY PITCH MOMENT CO	
2275	RTR 2,BLD 1,STA 14, UNSTEADY PITCH MOMENT CO	
2276	RTR 2,BLD 1,STA 13, UNSTEADY PITCH MOMENT CO	
2277	RTR 2,BLD 1,STA 12, UNSTEADY PITCH MOMENT CO	
2278	RTR 2,BLD 1,STA 11, UNSTEADY PITCH MOMENT CO	
2279	RTR 2,BLD 1,STA 10, UNSTEADY PITCH MOMENT CO	
2280	RTR 2,BLD 1,STA 9, UNSTEADY PITCH MOMENT CO	

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2281	RTR 2,BLD 1,STA 8, UNSTEADY PITCH MOMENT CO	
2282	RTR 2,BLD 1,STA 7, UNSTEADY PITCH MOMENT CO	
2283	RTR 2,BLD 1,STA 6, UNSTEADY PITCH MOMENT CO	
2284	RTR 2,BLD 1,STA 5, UNSTEADY PITCH MOMENT CO	
2285	RTR 2,BLD 1,STA 4 UNSTEADY PITCH MOMENT CO	
2286	RTR 2,BLD 1,STA 3 UNSTEADY PITCH MOMENT CO	
2287	RTR 2,BLD 1,STA 2 UNSTEADY PITCH MOMENT CO	
2288	RTR 2,BLD 1,STA 1 UNSTEADY PITCH MOMENT CO	
2289	RTR 2,BLD 1,STA 0, UNSTEADY PITCH MOMENT CO	
2290	RTR 2,BLD 1,STA 20, LIFT DISTRIBUTION	LBS/FT
2291	RTR 2,BLD 1,STA 19, LIFT DISTRIBUTION	LBS/FT
2292	RTR 2,BLD 1,STA 18, LIFT DISTRIBUTION	LBS/FT
2293	RTR 2,BLD 1,STA 17, LIFT DISTRIBUTION	LBS/FT
2294	RTR 2,BLD 1,STA 16, LIFT DISTRIBUTION	LBS/FT
2295	RTR 2,BLD 1,STA 15, LIFT DISTRIBUTION	LBS/FT
2296	RTR 2,BLD 1,STA 14, LIFT DISTRIBUTION	LBS/FT
2297	RTR 2,BLD 1,STA 13, LIFT DISTRIBUTION	LBS/FT
2298	RTR 2,BLD 1,STA 12, LIFT DISTRIBUTION	LBS/FT
2299	RTR 2,BLD 1,STA 11, LIFT DISTRIBUTION	LBS/FT
2300	RTR 2,BLD 1,STA 10, LIFT DISTRIBUTION	LBS/FT
2301	RTR 2,BLD 1,STA 9, LIFT DISTRIBUTION	LBS/FT
2302	RTR 2,BLD 1,STA 8, LIFT DISTRIBUTION	LBS/FT
2303	RTR 2,BLD 1,STA 7, LIFT DISTRIBUTION	LBS/FT
2304	RTR 2,BLD 1,STA 6, LIFT DISTRIBUTION	LBS/FT
2305	RTR 2,BLD 1,STA 5, LIFT DISTRIBUTION	LBS/FT
2306	RTR 2,BLD 1,STA 4 LIFT DISTRIBUTION	LBS/FT
2307	RTR 2,BLD 1,STA 3 LIFT DISTRIBUTION	LBS/FT
2308	RTR 2,BLD 1,STA 2 LIFT DISTRIBUTION	LBS/FT
2309	RTR 2,BLD 1,STA 1 LIFT DISTRIBUTION	LBS/FT
2310	RTR 2,BLD 1,STA 0, LIFT DISTRIBUTION	LBS/FT
2311	RTR 2,BLD 1,STA 20, DRAG DISTRIBUTION	LBS/FT
2312	RTR 2,BLD 1,STA 19, DRAG DISTRIBUTION	LBS/FT
2313	RTR 2,BLD 1,STA 18, DRAG DISTRIBUTION	LBS/FT
2314	RTR 2,BLD 1,STA 17, DRAG DISTRIBUTION	LBS/FT
2315	RTR 2,BLD 1,STA 16, DRAG DISTRIBUTION	LBS/FT
2316	RTR 2,BLD 1,STA 15, DRAG DISTRIBUTION	LBS/FT
2317	RTR 2,BLD 1,STA 14, DRAG DISTRIBUTION	LBS/FT
2318	RTR 2,BLD 1,STA 13, DRAG DISTRIBUTION	LBS/FT
2319	RTR 2,BLD 1,STA 12, DRAG DISTRIBUTION	LBS/FT
2320	RTR 2,BLD 1,STA 11, DRAG DISTRIBUTION	LBS/FT
2321	RTR 2,BLD 1,STA 10, DRAG DISTRIBUTION	LBS/FT
2322	RTR 2,BLD 1,STA 9, DRAG DISTRIBUTION	LBS/FT
2323	RTR 2,BLD 1,STA 8, DRAG DISTRIBUTION	LBS/FT
2324	RTR 2,BLD 1,STA 7, DRAG DISTRIBUTION	LBS/FT
2325	RTR 2,BLD 1,STA 6, DRAG DISTRIBUTION	LBS/FT
2326	RTR 2,BLD 1,STA 5, DRAG DISTRIBUTION	LBS/FT
2327	RTR 2,BLD 1,STA 4 DRAG DISTRIBUTION	LBS/FT
2328	RTR 2,BLD 1,STA 3 DRAG DISTRIBUTION	LBS/FT
2329	RTR 2,BLD 1,STA 2 DRAG DISTRIBUTION	LBS/FT
2330	RTR 2,BLD 1,STA 1 DRAG DISTRIBUTION	LBS/FT
2331	RTR 2,BLD 1,STA 0, DRAG DISTRIBUTION	LBS/FT
2332	RTR 2,BLD 1,STA 20, PITCHING MOMENT	FT-LB/FT
2333	RTR 2,BLD 1,STA 19, PITCHING MOMENT	FT-LB/FT
2334	RTR 2,BLD 1,STA 18, PITCHING MOMENT	FT-LB/FT
2335	RTR 2,BLD 1,STA 17, PITCHING MOMENT	FT-LB/FT
2336	RTR 2,BLD 1,STA 16, PITCHING MOMENT	FT-LB/FT
2337	RTR 2,BLD 1,STA 15, PITCHING MOMENT	FT-LB/FT
2338	RTR 2,BLD 1,STA 14, PITCHING MOMENT	FT-LB/FT
2339	RTR 2,BLD 1,STA 13, PITCHING MOMENT	FT-LB/FT
2340	RTR 2,BLD 1,STA 12, PITCHING MOMENT	FT-LB/FT

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2341	RTR 2,BLD 1,STA 11. PITCHING MOMENT	FT-LB/FT
2342	RTR 2,BLD 1,STA 10. PITCHING MOMENT	FT-LB/FT
2343	RTR 2,BLD 1,STA 9. PITCHING MOMENT	FT-LB/FT
2344	RTR 2,BLD 1,STA 8. PITCHING MOMENT	FT-LB/FT
2345	RTR 2,BLD 1,STA 7. PITCHING MOMENT	FT-LB/FT
2346	RTR 2,BLD 1,STA 6. PITCHING MOMENT	FT-LB/FT
2347	RTR 2,BLD 1,STA 5. PITCHING MOMENT	FT-LB/FT
2348	RTR 2,BLD 1,STA 4 PITCHING MOMENT	FT-LB/FT
2349	RTR 2,BLD 1,STA 3 PITCHING MOMENT	FT-LB/FT
2350	RTR 2,BLD 1,STA 2 PITCHING MOMENT	FT-LB/FT
2351	RTR 2,BLD 1,STA 1 PITCHING MOMENT	FT-LB/FT
2352	RTR 2,BLD 1,STA 0. PITCHING MOMENT	FT-LB/FT
2353	RTR 2,BLD 1,STA 20. TORQUE DISTRIBUTION	FT-LB/FT
2354	RTR 2,BLD 1,STA 19. TORQUE DISTRIBUTION	FT-LB/FT
2355	RTR 2,BLD 1,STA 18. TORQUE DISTRIBUTION	FT-LB/FT
2356	RTR 2,BLD 1,STA 17. TORQUE DISTRIBUTION	FT-LB/FT
2357	RTR 2,BLD 1,STA 16. TORQUE DISTRIBUTION	FT-LB/FT
2358	RTR 2,BLD 1,STA 15. TORQUE DISTRIBUTION	FT-LB/FT
2359	RTR 2,BLD 1,STA 14. TORQUE DISTRIBUTION	FT-LB/FT
2360	RTR 2,BLD 1,STA 13. TORQUE DISTRIBUTION	FT-LB/FT
2361	RTR 2,BLD 1,STA 12. TORQUE DISTRIBUTION	FT-LB/FT
2362	RTR 2,BLD 1,STA 11. TORQUE DISTRIBUTION	FT-LB/FT
2363	RTR 2,BLD 1,STA 10. TORQUE DISTRIBUTION	FT-LB/FT
2364	RTR 2,BLD 1,STA 9. TORQUE DISTRIBUTION	FT-LB/FT
2365	RTR 2,BLD 1,STA 8. TORQUE DISTRIBUTION	FT-LB/FT
2366	RTR 2,BLD 1,STA 7. TORQUE DISTRIBUTION	FT-LB/FT
2367	RTR 2,BLD 1,STA 6. TORQUE DISTRIBUTION	FT-LB/FT
2368	RTR 2,BLD 1,STA 5. TORQUE DISTRIBUTION	FT-LB/FT
2369	RTR 2,BLD 1,STA 4 TORQUE DISTRIBUTION	FT-LB/FT
2370	RTR 2,BLD 1,STA 3 TORQUE DISTRIBUTION	FT-LB/FT
2371	RTR 2,BLD 1,STA 2 TORQUE DISTRIBUTION	FT-LB/FT
2372	RTR 2,BLD 1,STA 1 TORQUE DISTRIBUTION	FT-LB/FT
2373	RTR 2,BLD 1,STA 0. TORQUE DISTRIBUTION	FT-LB/FT
2374	RTR 2,BLD 1,STA 20. INFLOW ANGLE	DEGREES
2375	RTR 2,BLD 1,STA 19. INFLOW ANGLE	DEGREES
2376	RTR 2,BLD 1,STA 18. INFLOW ANGLE	DEGREES
2377	RTR 2,BLD 1,STA 17. INFLOW ANGLE	DEGREES
2378	RTR 2,BLD 1,STA 16. INFLOW ANGLE	DEGREES
2379	RTR 2,BLD 1,STA 15. INFLOW ANGLE	DEGREES
2380	RTR 2,BLD 1,STA 14. INFLOW ANGLE	DEGREES
2381	RTR 2,BLD 1,STA 13. INFLOW ANGLE	DEGREES
2382	RTR 2,BLD 1,STA 12. INFLOW ANGLE	DEGREES
2383	RTR 2,BLD 1,STA 11. INFLOW ANGLE	DEGREES
2384	RTR 2,BLD 1,STA 10. INFLOW ANGLE	DEGREES
2385	RTR 2,BLD 1,STA 9. INFLOW ANGLE	DEGREES
2386	RTR 2,BLD 1,STA 8. INFLOW ANGLE	DEGREES
2387	RTR 2,BLD 1,STA 7. INFLOW ANGLE	DEGREES
2388	RTR 2,BLD 1,STA 6. INFLOW ANGLE	DEGREES
2389	RTR 2,BLD 1,STA 5. INFLOW ANGLE	DEGREES
2390	RTR 2,BLD 1,STA 4 INFLOW ANGLE	DEGREES
2391	RTR 2,BLD 1,STA 3 INFLOW ANGLE	DEGREES
2392	RTR 2,BLD 1,STA 2 INFLOW ANGLE	DEGREES
2393	RTR 2,BLD 1,STA 1 INFLOW ANGLE	DEGREES
2394	RTR 2,BLD 1,STA 0. INFLOW ANGLE	DEGREES
2395	RTR 2,BLD 1,STA 20. GEOMETRIC PITCH ANGLE	DEGREES
2396	RTR 2,BLD 1,STA 19. GEOMETRIC PITCH ANGLE	DEGREES
2397	RTR 2,BLD 1,STA 18. GEOMETRIC PITCH ANGLE	DEGREES
2398	RTR 2,BLD 1,STA 17. GEOMETRIC PITCH ANGLE	DEGREES
2399	RTR 2,BLD 1,STA 16. GEOMETRIC PITCH ANGLE	DEGREES
2400	RTR 2,BLD 1,STA 15. GEOMETRIC PITCH ANGLE	DEGREES

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2401	RTR 2.BLD 1.STA 14. GEOMETRIC PITCH ANGLE	DEGREES
2402	RTR 2.BLD 1.STA 13. GEOMETRIC PITCH ANGLE	DEGREES
2403	RTR 2.BLD 1.STA 12. GEOMETRIC PITCH ANGLE	DEGREES
2404	RTR 2.BLD 1.STA 11. GEOMETRIC PITCH ANGLE	DEGREES
2405	RTR 2.BLD 1.STA 10. GEOMETRIC PITCH ANGLE	DEGREES
2406	RTR 2.BLD 1.STA 9. GEOMETRIC PITCH ANGLE	DEGREES
2407	RTR 2.BLD 1.STA 8. GEOMETRIC PITCH ANGLE	DEGREES
2408	RTR 2.BLD 1.STA 7. GEOMETRIC PITCH ANGLE	DEGREES
2409	RTR 2.BLD 1.STA 6. GEOMETRIC PITCH ANGLE	DEGREES
2410	RTR 2.BLD 1.STA 5. GEOMETRIC PITCH ANGLE	DEGREES
2411	RTR 2.BLD 1.STA 4 GEOMETRIC PITCH ANGLE	DEGREES
2412	RTR 2.BLD 1.STA 3 GEOMETRIC PITCH ANGLE	DEGREES
2413	RTR 2.BLD 1.STA 2 GEOMETRIC PITCH ANGLE	DEGREES
2414	RTR 2.BLD 1.STA 1 GEOMETRIC PITCH ANGLE	DEGREES
2415	RTR 2.BLD 1.STA 0. GEOMETRIC PITCH ANGLE	DEGREES
2416	RTR 2.BLD 1.STA 20. LOCAL INDUCED VELOCITY	FT/SEC
2417	RTR 2.BLD 1.STA 19. LOCAL INDUCED VELOCITY	FT/SEC
2418	RTR 2.BLD 1.STA 18. LOCAL INDUCED VELOCITY	FT/SEC
2419	RTR 2.BLD 1.STA 17. LOCAL INDUCED VELOCITY	FT/SEC
2420	RTR 2.BLD 1.STA 16. LOCAL INDUCED VELOCITY	FT/SEC
2421	RTR 2.BLD 1.STA 15. LOCAL INDUCED VELOCITY	FT/SEC
2422	RTR 2.BLD 1.STA 14. LOCAL INDUCED VELOCITY	FT/SEC
2423	RTR 2.BLD 1.STA 13. LOCAL INDUCED VELOCITY	FT/SEC
2424	RTR 2.BLD 1.STA 12. LOCAL INDUCED VELOCITY	FT/SEC
2425	RTR 2.BLD 1.STA 11. LOCAL INDUCED VELOCITY	FT/SEC
2426	RTR 2.BLD 1.STA 10. LOCAL INDUCED VELOCITY	FT/SEC
2427	RTR 2.BLD 1.STA 9. LOCAL INDUCED VELOCITY	FT/SEC
2428	RTR 2.BLD 1.STA 8. LOCAL INDUCED VELOCITY	FT/SEC
2429	RTR 2.BLD 1.STA 7. LOCAL INDUCED VELOCITY	FT/SEC
2430	RTR 2.BLD 1.STA 6. LOCAL INDUCED VELOCITY	FT/SEC
2431	RTR 2.BLD 1.STA 5. LOCAL INDUCED VELOCITY	FT/SEC
2432	RTR 2.BLD 1.STA 4 LOCAL INDUCED VELOCITY	FT/SEC
2433	RTR 2.BLD 1.STA 3 LOCAL INDUCED VELOCITY	FT/SEC
2434	RTR 2.BLD 1.STA 2 LOCAL INDUCED VELOCITY	FT/SEC
2435	RTR 2.BLD 1.STA 1 LOCAL INDUCED VELOCITY	FT/SEC
2436	RTR 2.BLD 1.STA 0. LOCAL INDUCED VELOCITY	FT/SEC
2437	RTR 2.BLD 1.STA 20. LOCAL INFLOW VELOCITY	FT/SEC
2438	RTR 2.BLD 1.STA 19. LOCAL INFLOW VELOCITY	FT/SEC
2439	RTR 2.BLD 1.STA 18. LOCAL INFLOW VELOCITY	FT/SEC
2440	RTR 2.BLD 1.STA 17. LOCAL INFLOW VELOCITY	FT/SEC
2441	RTR 2.BLD 1.STA 16. LOCAL INFLOW VELOCITY	FT/SEC
2442	RTR 2.BLD 1.STA 15. LOCAL INFLOW VELOCITY	FT/SEC
2443	RTR 2.BLD 1.STA 14. LOCAL INFLOW VELOCITY	FT/SEC
2444	RTR 2.BLD 1.STA 13. LOCAL INFLOW VELOCITY	FT/SEC
2445	RTR 2.BLD 1.STA 12. LOCAL INFLOW VELOCITY	FT/SEC
2446	RTR 2.BLD 1.STA 11. LOCAL INFLOW VELOCITY	FT/SEC
2447	RTR 2.BLD 1.STA 10. LOCAL INFLOW VELOCITY	FT/SEC
2448	RTR 2.BLD 1.STA 9. LOCAL INFLOW VELOCITY	FT/SEC
2449	RTR 2.BLD 1.STA 8. LOCAL INFLOW VELOCITY	FT/SEC
2450	RTR 2.BLD 1.STA 7. LOCAL INFLOW VELOCITY	FT/SEC
2451	RTR 2.BLD 1.STA 6. LOCAL INFLOW VELOCITY	FT/SEC
2452	RTR 2.BLD 1.STA 5. LOCAL INFLOW VELOCITY	FT/SEC
2453	RTR 2.BLD 1.STA 4 LOCAL INFLOW VELOCITY	FT/SEC
2454	RTR 2.BLD 1.STA 3 LOCAL INFLOW VELOCITY	FT/SEC
2455	RTR 2.BLD 1.STA 2 LOCAL INFLOW VELOCITY	FT/SEC
2456	RTR 2.BLD 1.STA 1 LOCAL INFLOW VELOCITY	FT/SEC
2457	RTR 2.BLD 1.STA 0. LOCAL INFLOW VELOCITY	FT/SEC
2458	RTR 2.BLD 1.STA 20. LOCAL TANGENTIAL VELUCIT	FT/SEC
2459	RTR 2.BLD 1.STA 19. LOCAL TANGENTIAL VELOCIT	FT/SEC
2460	RTR 2.BLD 1.STA 18. LOCAL TANGENTIAL VELOCIT	FT/SEC

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2461	RTR 2,BLD 1,STA 17, LOCAL TANGENTIAL VELOCIT	FT/SEC
2462	RTR 2,BLD 1,STA 16, LOCAL TANGENTIAL VELOCIT	FT/SEC
2463	RTR 2,BLD 1,STA 15, LOCAL TANGENTIAL VELOCIT	FT/SEC
2464	RTR 2,BLD 1,STA 14, LOCAL TANGENTIAL VELOCIT	FT/SEC
2465	RTR 2,BLD 1,STA 13, LOCAL TANGENTIAL VELOCIT	FT/SEC
2466	RTR 2,BLD 1,STA 12, LOCAL TANGENTIAL VELOCIT	FT/SEC
2467	RTR 2,BLD 1,STA 11, LOCAL TANGENTIAL VELOCIT	FT/SEC
2468	RTR 2,BLD 1,STA 10, LOCAL TANGENTIAL VELOCIT	FT/SEC
2469	RTR 2,BLD 1,STA 9, LOCAL TANGENTIAL VELOCIT	FT/SEC
2470	RTR 2,BLD 1,STA 8, LOCAL TANGENTIAL VELOCIT	FT/SEC
2471	RTR 2,BLD 1,STA 7, LOCAL TANGENTIAL VELOCIT	FT/SEC
2472	RTR 2,BLD 1,STA 6, LOCAL TANGENTIAL VELOCIT	FT/SEC
2473	RTR 2,BLD 1,STA 5, LOCAL TANGENTIAL VELOCIT	FT/SEC
2474	RTR 2,BLD 1,STA 4 LOCAL TANGENTIAL VELOCIT	FT/SEC
2475	RTR 2,BLD 1,STA 3 LOCAL TANGENTIAL VELOCIT	FT/SEC
2476	RTR 2,BLD 1,STA 2 LOCAL TANGENTIAL VELOCIT	FT/SEC
2477	RTR 2,BLD 1,STA 1 LOCAL TANGENTIAL VELOCIT	FT/SEC
2478	RTR 2,BLD 1,STA 0, LOCAL TANGENTIAL VELOCIT	FT/SEC
2479	RTR 2,BLD 1,STA 20, LOCAL RADIAL VELOCITY	FT/SEC
2480	RTR 2,BLD 1,STA 19, LOCAL RADIAL VELOCITY	FT/SEC
2481	RTR 2,BLD 1,STA 18, LOCAL RADIAL VELOCITY	FT/SEC
2482	RTR 2,BLD 1,STA 17, LOCAL RADIAL VELOCITY	FT/SEC
2483	RTR 2,BLD 1,STA 16, LOCAL RADIAL VELOCITY	FT/SEC
2484	RTR 2,BLD 1,STA 15, LOCAL RADIAL VELOCITY	FT/SEC
2485	RTR 2,BLD 1,STA 14, LOCAL RADIAL VELOCITY	FT/SEC
2486	RTR 2,BLD 1,STA 13, LOCAL RADIAL VELOCITY	FT/SEC
2487	RTR 2,BLD 1,STA 12, LOCAL RADIAL VELOCITY	FT/SEC
2488	RTR 2,BLD 1,STA 11, LOCAL RADIAL VELOCITY	FT/SEC
2489	RTR 2,BLD 1,STA 10, LOCAL RADIAL VELOCITY	FT/SEC
2490	RTR 2,BLD 1,STA 9, LOCAL RADIAL VELOCITY	FT/SEC
2491	RTR 2,BLD 1,STA 8, LOCAL RADIAL VELOCITY	FT/SEC
2492	RTR 2,BLD 1,STA 7, LOCAL RADIAL VELOCITY	FT/SEC
2493	RTR 2,BLD 1,STA 6, LOCAL RADIAL VELOCITY	FT/SEC
2494	RTR 2,BLD 1,STA 5, LOCAL RADIAL VELOCITY	FT/SEC
2495	RTR 2,BLD 1,STA 4 LOCAL RADIAL VELOCITY	FT/SEC
2496	RTR 2,BLD 1,STA 3 LOCAL RADIAL VELOCITY	FT/SEC
2497	RTR 2,BLD 1,STA 2 LOCAL RADIAL VELOCITY	FT/SEC
2498	RTR 2,BLD 1,STA 1 LOCAL RADIAL VELOCITY	FT/SEC
2499	RTR 2,BLD 1,STA 0, LOCAL RADIAL VELOCITY	FT/SEC
2500	RTR 2,BLD 1,STA 20, YAWED FLOW ANGLE	DEGREES
2501	RTR 2,BLD 1,STA 19, YAWED FLOW ANGLE	DEGREES
2502	RTR 2,BLD 1,STA 18, YAWED FLOW ANGLE	DEGREES
2503	RTR 2,BLD 1,STA 17, YAWED FLOW ANGLE	DEGREES
2504	RTR 2,BLD 1,STA 16, YAWED FLOW ANGLE	DEGREES
2505	RTR 2,BLD 1,STA 15, YAWED FLOW ANGLE	DEGREES
2506	RTR 2,BLD 1,STA 14, YAWED FLOW ANGLE	DEGREES
2507	RTR 2,BLD 1,STA 13, YAWED FLOW ANGLE	DEGREES
2508	RTR 2,BLD 1,STA 12, YAWED FLOW ANGLE	DEGREES
2509	RTR 2,BLD 1,STA 11, YAWED FLOW ANGLE	DEGREES
2510	RTR 2,BLD 1,STA 10, YAWED FLOW ANGLE	DEGREES
2511	RTR 2,BLD 1,STA 9, YAWED FLOW ANGLE	DEGREES
2512	RTR 2,BLD 1,STA 8, YAWED FLOW ANGLE	DEGREES
2513	RTR 2,BLD 1,STA 7, YAWED FLOW ANGLE	DEGREES
2514	RTR 2,BLD 1,STA 6, YAWED FLOW ANGLE	DEGREES
2515	RTR 2,BLD 1,STA 5, YAWED FLOW ANGLE	DEGREES
2516	RTR 2,BLD 1,STA 4 YAWED FLOW ANGLE	DEGREES
2517	RTR 2,BLD 1,STA 3 YAWED FLOW ANGLE	DEGREES
2518	RTR 2,BLD 1,STA 2 YAWED FLOW ANGLE	DEGREES
2519	RTR 2,BLD 1,STA 1 YAWED FLOW ANGLE	DEGREES
2520	RTR 2,BLD 1,STA 0, YAWED FLOW ANGLE	DEGREES

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2521	RTR 2,BLD 1,STA 20, OUT OF PLANE DEFLECTION	FEET
2522	RTR 2,BLD 1,STA 19, OUT OF PLANE DEFLECTION	FEET
2523	RTR 2,BLD 1,STA 18, OUT OF PLANE DEFLECTION	FEET
2524	RTR 2,BLD 1,STA 17, OUT OF PLANE DEFLECTION	FEET
2525	RTR 2,BLD 1,STA 16, OUT OF PLANE DEFLECTION	FEET
2526	RTR 2,BLD 1,STA 15, OUT OF PLANE DEFLECTION	FEET
2527	RTR 2,BLD 1,STA 14, OUT OF PLANE DEFLECTION	FEET
2528	RTR 2,BLD 1,STA 13, OUT OF PLANE DEFLECTION	FEET
2529	RTR 2,BLD 1,STA 12, OUT OF PLANE DEFLECTION	FEET
2530	RTR 2,BLD 1,STA 11, OUT OF PLANE DEFLECTION	FEET
2531	RTR 2,BLD 1,STA 10, OUT OF PLANE DEFLECTION	FEET
2532	RTR 2,BLD 1,STA 9, OUT OF PLANE DEFLECTION	FEET
2533	RTR 2,BLD 1,STA 8, OUT OF PLANE DEFLECTION	FEET
2534	RTR 2,BLD 1,STA 7, OUT OF PLANE DEFLECTION	FEET
2535	RTR 2,BLD 1,STA 6, OUT OF PLANE DEFLECTION	FEET
2536	RTR 2,BLD 1,STA 5, OUT OF PLANE DEFLECTION	FEET
2537	RTR 2,BLD 1,STA 4 OUT OF PLANE DEFLECTION	FEET
2538	RTR 2,BLD 1,STA 3 OUT OF PLANE DEFLECTION	FEET
2539	RTR 2,BLD 1,STA 2 OUT OF PLANE DEFLECTION	FEET
2540	RTR 2,BLD 1,STA 1 OUT OF PLANE DEFLECTION	FEET
2541	RTR 2,BLD 1,STA 0, OUT OF PLANE DEFLECTION	FEET
2542	RTR 2,BLD 1,STA 20, IN PLANE DEFLECTION	FEET
2543	RTR 2,BLD 1,STA 19, IN PLANE DEFLECTION	FEET
2544	RTR 2,BLD 1,STA 18, IN PLANE DEFLECTION	FEET
2545	RTR 2,BLD 1,STA 17, IN PLANE DEFLECTION	FEET
2546	RTR 2,BLD 1,STA 16, IN PLANE DEFLECTION	FEET
2547	RTR 2,BLD 1,STA 15, IN PLANE DEFLECTION	FEET
2548	RTR 2,BLD 1,STA 14, IN PLANE DEFLECTION	FEET
2549	RTR 2,BLD 1,STA 13, IN PLANE DEFLECTION	FEET
2550	RTR 2,BLD 1,STA 12, IN PLANE DEFLECTION	FEET
2551	RTR 2,BLD 1,STA 11, IN PLANE DEFLECTION	FEET
2552	RTR 2,BLD 1,STA 10, IN PLANE DEFLECTION	FEET
2553	RTR 2,BLD 1,STA 9, IN PLANE DEFLECTION	FEET
2554	RTR 2,BLD 1,STA 8, IN PLANE DEFLECTION	FEET
2555	RTR 2,BLD 1,STA 7, IN PLANE DEFLECTION	FEET
2556	RTR 2,BLD 1,STA 6, IN PLANE DEFLECTION	FEET
2557	RTR 2,BLD 1,STA 5, IN PLANE DEFLECTION	FEET
2558	RTR 2,BLD 1,STA 4 IN PLANE DEFLECTION	FEET
2559	RTR 2,BLD 1,STA 3 IN PLANE DEFLECTION	FEET
2560	RTR 2,BLD 1,STA 2 IN PLANE DEFLECTION	FEET
2561	RTR 2,BLD 1,STA 1 IN PLANE DEFLECTION	FEET
2562	RTR 2,BLD 1,STA 0, IN PLANE DEFLECTION	FEET
2563	RTR 2,BLD 1,STA 20, TORSIONAL DEFLECTION	DEGREES
2564	RTR 2,BLD 1,STA 19, TORSIONAL DEFLECTION	DEGREES
2565	RTR 2,BLD 1,STA 18, TORSIONAL DEFLECTION	DEGREES
2566	RTR 2,BLD 1,STA 17, TORSIONAL DEFLECTION	DEGREES
2567	RTR 2,BLD 1,STA 16, TORSIONAL DEFLECTION	DEGREES
2568	RTR 2,BLD 1,STA 15, TORSIONAL DEFLECTION	DEGREES
2569	RTR 2,BLD 1,STA 14, TORSIONAL DEFLECTION	DEGREES
2570	RTR 2,BLD 1,STA 13, TORSIONAL DEFLECTION	DEGREES
2571	RTR 2,BLD 1,STA 12, TORSIONAL DEFLECTION	DEGREES
2572	RTR 2,BLD 1,STA 11, TORSIONAL DEFLECTION	DEGREES
2573	RTR 2,BLD 1,STA 10, TORSIONAL DEFLECTION	DEGREES
2574	RTR 2,BLD 1,STA 9, TORSIONAL DEFLECTION	DEGREES
2575	RTR 2,BLD 1,STA 8, TORSIONAL DEFLECTION	DEGREES
2576	RTR 2,BLD 1,STA 7, TORSIONAL DEFLECTION	DEGREES
2577	RTR 2,BLD 1,STA 6, TORSIONAL DEFLECTION	DEGREES
2578	RTR 2,BLD 1,STA 5, TORSIONAL DEFLECTION	DEGREES
2579	RTR 2,BLD 1,STA 4 TORSIONAL DEFLECTION	DEGREES
2580	RTR 2,BLD 1,STA 3 TORSIONAL DEFLECTION	DEGREES

TABLE 28. (Continued)

NUMBER	DESCRIPTION	UNITS
2581	RTR 2.BLD 1.STA 2 TORSIONAL DEFLECTION	DEGREES
2582	RTR 2.BLD 1.STA 1 TORSIONAL DEFLECTION	DEGREES
2583	RTR 2.BLD 1.STA 0. TORSIONAL DEFLECTION	DEGREES
2584	NOT USED	
2585	NOT USED	
2586	NOT USED	
2587	NOT USED	
2588	NOT USED	
2589	NOT USED	
2590	NOT USED	
2591	NOT USED	
2592	NOT USED	
2593	NOT USED	
2594	NOT USED	
2595	NOT USED	
2596	NOT USED	
2597	NOT USED	
2598	NOT USED	
2599	NOT USED	
2600	NOT USED	
2601	NOT USED	
2602	NOT USED	
2603	NOT USED	
2604	NOT USED	
2605	NOT USED	
2606	NOT USED	
2607	NOT USED	
2608	NOT USED	
2609	NOT USED	
2610	NOT USED	
2611	NOT USED	
2612	NOT USED	
2613	NOT USED	
2614	NOT USED	
2615	NOT USED	
2616	NOT USED	
2617	NOT USED	
2618	NOT USED	
2619	NOT USED	
2620	NOT USED	
2621	NOT USED	
2622	NOT USED	
2623	NOT USED	
2624	NOT USED	
2625	NOT USED	
2626	DESIRED ROLL RATE	DEG/SEC
2627	DESIRED PITCH RATE	DEG/SEC
2628	DESIRED YAW RATE	DEG/SEC
2629	DESIRED NORMAL LOAD	G
2630	DESIRED RATE-OF-CLIMB	FT/SEC
2631	ROTOR 1. FILTERED THRUST	POUNDS
2632	ROTOR 2. FILTERED THRUST	POUNDS
2633	ROTOR 1. FILTERED H-FORCE	POUNDS
2634	ROTOR 2. FILTERED H-FORCE	POUNDS
2635	ROTOR 1. FILTERED Y-FORCE	POUNDS
2636	ROTOR 2. FILTERED Y-FORCE	POUNDS
2637	FILTERED NORMAL LOAD FACTOR	G
2638	FILTERED CG BODY X-FORCE	POUNDS
2639	FILTERED CG BODY Y-FORCE	POUNDS
2640	FILTERED CG BODY Z-FORCE	POUNDS

TABLE 28. (Concluded)

IMBER	DESCRIPTION	UNITS
2641	FILTERED CG BODY ROLL MOMENT	FL-LB
2642	FILTERED CG BODY PITCH MOMENT	FT-LB
2643	FILTERED CG BODY YAW MOMENT	FT-LB
2644	X-ACC AT A SPECIFIED POINT, BODY AXIS	G
2645	Y-ACC AT A SPECIFIED POINT, BODY AXIS	G
2646	Z-ACC AT A SPECIFIED POINT, BODY AXIS	G
2647	ROLL ACCELERATION AT A SPECIFIED POINT, BODY	RAD/SEC**2
2648	PITCH ACCELERATION AT A SPECIFIED POINT, BOD	RAD/SEC**2
2649	YAW ACCELERATION AT A SPECIFIED POINT, BODY	RAD/SEC**2
2650	NOT USED	
2651	NOT USED	
2652	NOT USED	
2653	NOT USED	
2654	NOT USED	
2655	NOT USED	
2656	NOT USED	
2657	NOT USED	
2658	NOT USED	
2659	NOT USED	
2660	NOT USED	
2661	NOT USED	
2662	NOT USED	
2663	NOT USED	
2664	NOT USED	
2665	NOT USED	
2666	NOT USED	
2667	NOT USED	
2668	NOT USED	
2669	NOT USED	
2670	NOT USED	
2671	NOT USED	
2672	NOT USED	
2673	NOT USED	
2674	NOT USED	
2675	NOT USED	
2676	NOT USED	
2677	NOT USED	
2678	NOT USED	
2679	NOT USED	
2680	NOT USED	
2681	NOT USED	
2682	NOT USED	
2683	NOT USED	
2684	NOT USED	
2685	NOT USED	
2686	NOT USED	
2687	NOT USED	
2688	NOT USED	
2689	NOT USED	
2690	NOT USED	
2691	NOT USED	
2692	NOT USED	
2693	NOT USED	
2694	NOT USED	
2695	NOT USED	
2696	NOT USED	
2697	NOT USED	
2698	NOT USED	
2699	NOT USED	
2700	NOT USED	

TABLE 29. PLOT CODES FOR BENDING MOMENTS AT EACH STATION ON BLADE 1 OF ROTOR 1

STATION (Root to tip)	BEAM	CHORD	TORSION
0 (0% R)	766	913	1060
1	759	906	1053
2	752	899	1046
3	745	892	1039
4	738	885	1032
5	731	878	1025
6	724	871	1018
7	717	864	1011
8	710	857	1004
9	703	850	997
10	691	843	990
11	689	836	983
12	682	829	976
13	675	822	969
14	668	815	962
15	661	808	955
16	654	801	948
17	647	794	941
18	640	787	934
19	633	780	927
20	626	773	920

10. AUXILIARY PROGRAMS

Three digital computer programs, DNAM05, AR9102, and AN9101, are used to prepare C81 input data. Program DNAM05 is used to compute coupled rotor natural frequencies and mode shapes from a set of blade structural parameters, AR9102 computes the rotor-induced velocity distribution, and AN9101 converts airframe wind tunnel test data to the AGAP80 input format. All three programs can punch their output for direct inclusion in an AGAP80 deck. DNAM05 and AR9102 are coded in FORTRAN IV while AN9101 is a PL/1 program.

10.1 ROTOR NATURAL FREQUENCY PROGRAM DNAM05

10.1.1 Analytical Model

The analysis incorporated in this program is described in Section 3.2 of Volume I of Reference 1.

DNAM05 computes the natural frequencies and mode shapes of the rotor described by the user's input. The program assumes a natural frequency ω, solves a matrix equation with five known boundary conditions, and then finds the value of ω for which the resulting polynomial is zero. Three types of mode shapes are computed and printed, depending upon rotor type, as follows: (1) hingeless or articulated-collective and scissors, (2) teetering or gimbaled (2, 3 or 5 blades)-collective and cyclic, (3) teetering or gimbaled (4 or 6 blades)-collective, cyclic and scissors. Note that if SLAMUR is specified, all mode types will be computed and printed.

A maximum of 40 blade segments allows the user to make a detailed dynamic definition in the areas of interest. Blade segment data must be input in order out the blade to prevent negative segment lengths from being generated. Numerical problems may result if segment lengths less than 1% of the radius are used.

In the hub region, the beamwise and chordwise offsets of the cg, neutral axis, and shear center are defined relative to a radial axis through the center of rotation. The hub segments are all segments which lie entirely inboard of the radius where the blade reference system starts, RBCS. (See Figures 81 and 82.) For linear twist distributions, the blade twist is given as:

$$\Theta_i = 0 \text{ for } i < \text{LPHOFF}$$

$$\Theta_i = (\text{Twist}/R_{Tip})R_i + \text{THINC for } i > \text{LPHOFF}.$$

All offsets measured relative to Hub Reference Axis inboard of RBCS, as at 1.

All offsets measured relative to Blade System Reference Axis outboard of RBCS, as at 2.

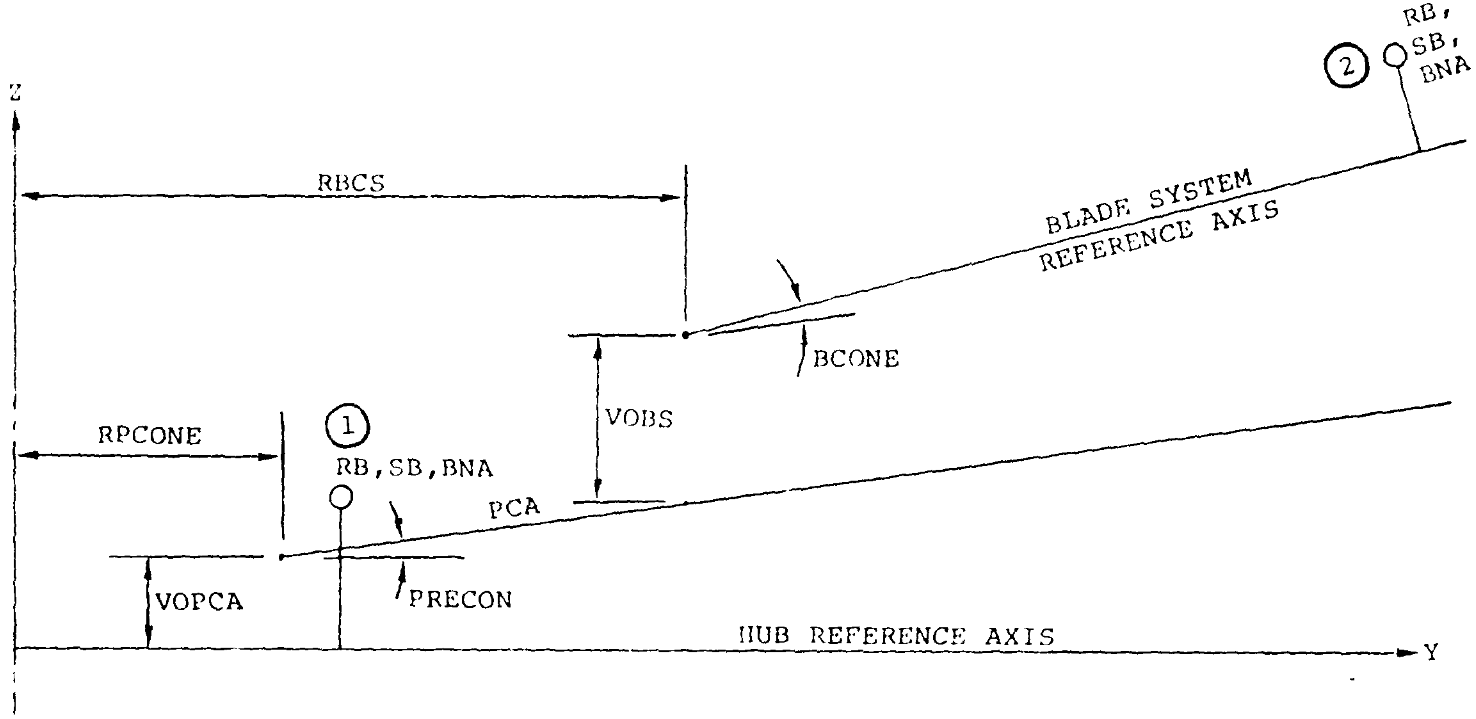
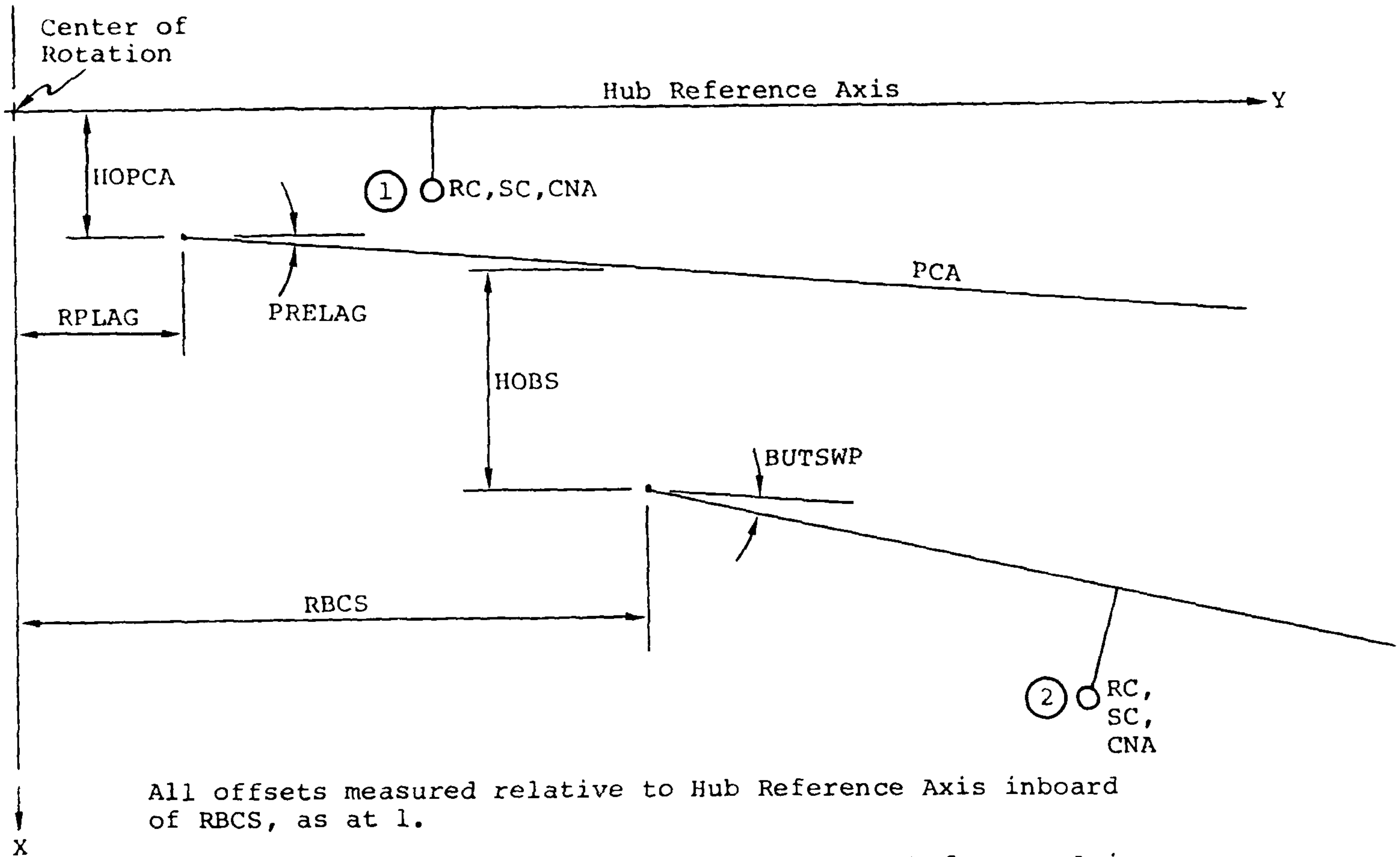


Figure 81. *Out-of-Plane Offsets and Slopes for PCA and Blade System Axes.*



All offsets measured relative to Hub Reference Axis inboard of RBCS, as at 1.

All offsets measured relative to Blade System Reference Axis outboard of RBCS, as at 2.

Figure 82. Inplane Offsets and Slopes for PCA and Blade System Axes.

The input linear twist should be based on the full radius even though the twist is zero inside of JHUB.

Outboard of RBCS, the cg, neutral axis, and shear center offsets are defined relative to an arbitrary blade reference system. It has been assumed that the blade built-in twist is a rotation about the blade reference axis, although this should only be significant for highly twisted rotors. The PCA (Pitch Change Axis) is used as the reference for all internal calculations. The necessary transformations are made for each value of collective pitch.

In order to model articulation hinges, DNAM05 will accept a zero EI input for a segment in either the beamwise or chordwise direction, or the inputs for hinge offsets. If a zero EI is input, it is best to use the zero EI for a short segment with the unequal segment option because that segment is modeled as a rigid element with a pin joint at the inboard end. The inputs for flapping spring and lag spring may be used for restraint about the hinges if desired.

There are four inputs which describe the geometry of the hub for torsional behavior. The input for the number of nonfeathering hub segments (JHUB) is used in all cases, but serves an additional purpose when torsion is used. The feathering bearings are assumed to be just outboard of segment number JHUB or the distance PHOFF (the radial location of the pitch horn attachment), whichever is less. The feathering bearings are modeled as one segment with a very small torsional stiffness. This value is set internally to 10^{-4} times GI for the tip segment or 10^{-4}*CK/ZBAR(N), whichever is larger. If the rotor being modeled does not have feathering bearings, the user should input JHUB as zero. This will activate the bearingless rotor model, which does not modify the GI values input. The pitch horn geometry is sketched in Figure 83.

The inputs PHOFF, PARM, PHMASS, PHMR, PHMC, PHMB, EIPH and PLSTA, along with the control system spring rate, determine the torsional moment, vertical shear and out-of-plane bending moment put into the blade from the pitch horn and control system. The pitch horn model described by these inputs will give rise to pitch-flap and pitch-cone coupling independent of the hinge skew angle inputs. It is necessary for rotors with a feathering bearing (JHUB>0) to have PHOFF$\geq$Z(2) or no feathering bearing is modeled.

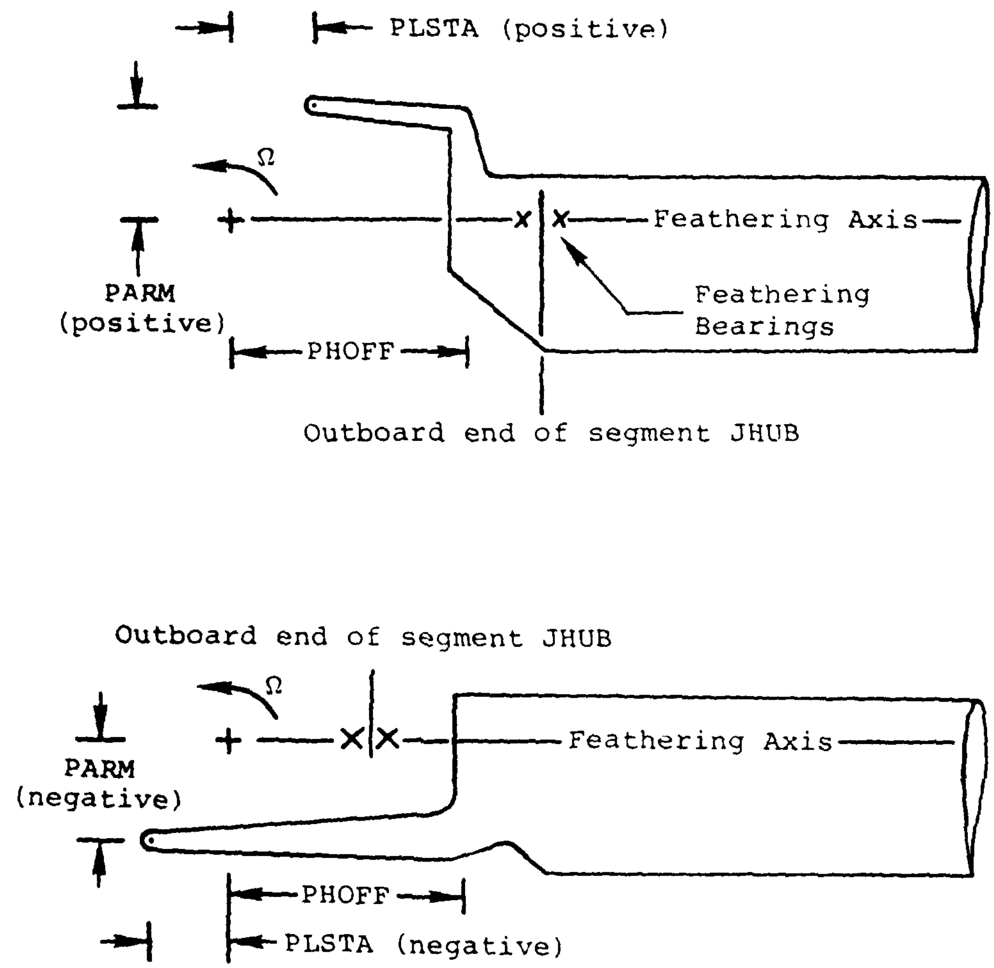


Figure 83. Definition of Pitch Horn Geometry.

10.1.2 Restrictions

The maximum number of segments is 40. The maximum number of segments to be punched is 20. If NEWPUNCH or SLAMUR is specified, the user may request a maximum of 14 punched modes. XNIN and XNOUT may not be changed under the NAMELIST option. If the number of hub segments is to be changed, the variable JHUB must be input in integer form. Blade segment data must be input in order out the blade. Segment length should be greater than 1% of the radius. The control word DECK or READONLY must appear on the second card of each DNAM05 deck. If NEWPUNCH or SLAMUR are to be used for any subsequent cases, it must appear on the first CARD 2 of the deck. PHOFF$\geq$Z(2) is required to permit a feathering bearing model.

Some input is required only if certain options are specified on CARD 2.

10.2 INPUT GUIDE FOR DNAM05

This section contains all the information necessary to set up a DNAM05 deck. Since the input format varies from card to card, the format will be given for each card. The NAMELIST name of those variables which can be changed on an &INPUT card will also be given.

10.2.1 Input Format for DNAM05

CARD 1 (20A4)

80 columns of alphanumeric data giving the user's name, group, telephone extension and any special run disposition instructions.

CARD 2 Control Card (7(A4,6X))

This card contains the program control instructions. The words do not need to be in a particular order, but they must be left-justified in each 10-column field, i.e., the words must start in columns 1, 11, 21, etc. The control word DECK must appear on the second card of each DNAM05 deck.

Control Words	
DECK	Read full data deck
READONLY	Read full data deck, skip execution and go to first NAMELIST
NAMELIST	Read changes to previous case (see 10.2.2)

PUNCH	Punch elastic data for input to C81 (pre-1976 format)
NEWPUNCH	Punch elastic data for input to C81 in new format (must be on first CARD 2 if it will be used for any subsequent case)
SLAMUR	Punch elastic data for input to the SLAMUR version of C81 (must be on first CARD 2 if used anywhere in deck)
MODES	Print mode shapes at one combination of rpm and collective pitch
ALLMODES	Print all calculated mode shapes
PLOT	Make fan plots on CALCOMP (Type 401-A paper)
TORSION	Read and/or use torsion data
TWIST	Read and/or use nonlinear twist distribution
NOT20	The number of segments used will not be 20. Input number of segments to be input on CARD 6.
UNEQUAL	The unequal segment length option will be used
END	End problem

CARD 3 (A4, A3, IX, 18A4)

NAME	7-column alphanumeric problem identification name
ITLE	72-column alphanumeric problem description. The first 40 characters are printed on one line and the last 32 characters are printed below them.

CARD 4 (7F10.0)

Column			
1-10	JHUB	Number of nonfeathering hub segments	
11-20	TORSO	Effective torsional spring rate of drive system per blade/10^6	$\left(\frac{\text{in.-lb}}{\text{rad}}\right)$
21-30	VMASS	Effective vertical hub mass per blade	(lb_m)

31-40	HMASS	Effective inplane hub mass per blade	(lb_m)
41-50	VSOFT	Effective vertical restraint/10^6	$\left(\frac{1}{lb}\right)$
51-60	HSOFT	Effective inplane restraint/10^6	$\left(\frac{1}{lb}\right)$
61-70	RSOFT	Flapping spring rate for flapping restraint at center of rotation (gimbaled rotors only), per blade	$\left(\frac{ft\text{-}lb}{deg}\right)$
CARD 5	(7F10.0)		
1-10	AZBAR	Segment length for equal segments	(in.)
11-20	RPMA	Initial rpm	(rpm)
21-30	RPMB	Intermediate rpm	(rpm)
31-40	RPMC	Final rpm	(rpm)
41-50	COLLA	Initial root collective - measured at center of rotation	(deg)
51-60	COLLB	Intermediate root collective	(deg)
61-70	COLLC	Final root collective	(deg)
CARD 6	(7F10.0)		
1-10	TWIST	Rotor linear twist, washout negative	(deg)
11-20	BLADES	Number of blades	
21-30	CHORD	Chord	(in.)
31-40	PSQR	Initial frequency in sweep (Default value = .1*RPMA)	(/rev)
41-50	DP	Delta frequency in sweep (Default value = 0.25*max (RPMA, RPMB, RPMC))	(/rev)
51-60	PLAST	Final frequency in sweep (Default value = 10*max (RPMA, RPMB, RPMC))	(/rev)
61-70	HUBTYP	Hub type indicator; 0 for teetering or gimbaled; 1 for articulated or hingeless	

CARD 7 (7F10.0)

1-10	XNIN	Number of segments to be input (40 maximum)	
11-20	XNOUT	Number of segments to be punched for C81 (20 maximum)	
21-30	CK	Control system spring rate	$\left(\frac{\text{in.-lb}}{\text{rad}}\right)$
31-40	CDAMP	Control system damping (based on that for a nonrotating, rigid blade)	(%)
41-50	PHOFF	Pitch-horn radial attachment point	(in.)
51-60	PARM	Pitch-horn moment arm about pitch-change axis (positive for leading edge pitch horn)	(in.)
61-70	PLSTA	Radial station where pitch horn is attached to the pitch link	(in.)

CARD 8 (7F10.0)

1-10	FHOFF	Flapping hinge radial station	(in.)
11-20	FLPSPR	Rate of flapping spring at offset flapping hinge	$\left(\frac{\text{ft-lb}}{\text{deg}}\right)$
21-30	FHANGL	Skew angle of flapping hinge that yields pitch-flap coupling (positive for pitch down with up flapping)	(deg)
31-40	CHOFF	Lag hinge radial station	(in.)
41-50	SPRLG	Spring rate for lag spring	$\left(\frac{\text{ft-lb}}{\text{deg}}\right)$
51-60	ALPHAI	Skew angle of lag hinge which yields flap-lag coupling (positive for flap up, lag aft)	(deg)
61-70	ALPHA3	Skew angle of lag hinge which yields pitch-lag coupling (positive pitch up for lag aft)	(deg)

CARD 9 (6F10.0)

1-10	RPCONE	Radius where rotor precone begins (the out-of-plane geometry is shown in Figure 75)	(in.)

11-20	PRECON	Precone angle (out-of-plane) of the pitch-change axis (PCA)	(deg)
21-30	VOPCA	Vertical offset of the PCA at radius = RPCONE	(in.)
31-40	RPLAG	Radius where rotor prelag begins (the inplane geometry is shown in Figure 76)	(in.)
41-50	PRELAG	Prelag angle (inplane) of the PCA	(deg)
51-60	HOPCA	Horizontal offset of the PCA at radius = RPLAG	(in.)

CARD 10 (6F10.0)

1-10	RBCS	Radius where the blade coordinate system starts	(in.)
11-20	BCONE	Out-of-plane angle of the blade coordinate system relative to the PCA at 0° collective pitch	(deg)
21-30	VOBS	Vertical offset of the blade coordinate system from the PCA at 0° collective and radius = RBCS	(in.)
31-40	BUTSWP	Inplane angle of the blade coordinate system relative to the PCA at 0° collective	(deg)
41-50	HOBS	Horizontal offset of the blade coordinate system from the PCA at 0° collective and radius = RBCS	(in.)
51-60	THINC	Twist increment at PHOFF for linear twist	(deg)

CARD 11 (5F10.0)

Card 11 currently has no active inputs.

The rotor blade structural properties are input on the next XNIN cards (or 2*XNIN cards if TORSION was listed on CARD 2), from zero radius to the tip.

CARD 12 (7F10.0)

Blade Parameters for Segment

Columns	Variable	Description	Units
1-10	Z(2)	Distance from center of rotation to outboard end of segment. (May be zero for equal segments)	(in.)
11-20	WTPL(1)	Average weight per inch for segment	(lb/in.)
21-30	EIB(1)	Effective beamwise stiffness/ 10^6 for segment	(lb-in.^{2})
31-40	EIC(1)	Effective chordwise stiffness/ 10^6 for segment	(lb-in.^{2})
41-50	THD(2)	Twist angle at outboard end of segment. (May be input as zero for linear twist)	(deg)
51-60	RB(1)	Beamwise offset of cg for segment (+ up)	(in.)
61-70	RC(1)	Chordwise offset of cg for segment (+ aft)	(in.)

CARD 12A (7F10.0)

OPTIONAL: Include only if TORSION was listed on CARD 2.

Columns	Variable	Description	Units
1-10	EYEB(1)	Average beamwise mass moment of inertia for segment	(in.-lb-sec^2/in.)
11-20	EYEC(1)	Average chordwise mass moment of inertia for segment	(in.-lb-sec^2/in.)
	NOTE:	EYEC >> EYEB	
21-30	GI(1)	Effective torsional stiffness/ 10^6 for segment	(lb-in.^{2})
31-40	SB(1)	Beamwise shear center offset for segment (+ up)	(in.)
41-50	SC(1)	Chordwise shear center offset for segment (+ aft)	(in.)

51-60	BNA(1)	Beamwise neutral axis offset for segment (+ up)	(in.)
61-70	CNA(1)	Chordwise neutral axis offset for segment (+ aft)	(in.)

CARD 13 (CARD 13A), CARD 14 (CARD 14A), through CARD XNIN+11 (CARD XNIN+11)A) contain the structural properties for the remaining segments of the blade, in the same format as CARD 12 and CARD 12A.

CARD XNIN+12 (4F10.0)

1-10	TIPWT	Additional balance weight (at 99% radius)	(lb)
11-20	RB(N+1)	Beamwise cg offset for tip weight	(in.)
21-30	RC(N+1)	Chordwise cg offset for tip weight	(in.)
31-40	FUNC	Low rpm to be used for uncoupled modes if PLOT was specified on CARD 2. (Default value is 1/3 RPMA)	(rpm)

CARDS XNIN+13, XNIN+14 (14I5)

OPTIONAL: If NEWPUNCH was specified on CARD 2 and XNOUT on CARD 7 is less than XNIN

ICUT — This card lists the station numbers for the stations to be eliminated in the punched output, in ascending order (XNIN-XNOUT values). ICUT is in 5 column fields without decimal (I5 format), 14 per card. The second card is omitted if less than 15 inputs are needed. Station 0 is at radius 0.0, and cannot be eliminated. Station 1 is at radius Z(2), Station 2 is at radius Z(3), etc. Station XNIN may not be eliminated.

CARD XNIN+15 (14I5)

NOTE: This card must be input if NEWPUNCH has been specified. If XNIN=XNOUT, it replaces CARDS XNIN+8 and XNIN+9. The card contains a series of right-justified integers specifying which mode shapes are to be punched.

Cyclic modes are denoted by negative integers, collective modes by positive integers and scissors modes by integers in excess of 100. The value of the integer (or the value minus 100 for

scissors modes) indicates which modes of that type are to be punched. The first cyclic mode found by the program would be specified by -1, the third collective mode found would be specified by 3, and the second scissors mode found would be selected by 102.

The appropriate subscripted namelist variable is MODEP.

10.2.2 Parameter Sweeps Using NAMELIST

A range of values may be swept for a variable by running additional cases using the NAMELIST option. Three additional cards are required for each extra case:

a. Another CARD 2. Include NAMELIST and all options desired for this case.

b. Another CARD 3. The user changes ID number and description for each case.

c. Parameter changes for this case from the preceding case are made in the following form:

   &INPUT variable$_1$ = number$_1$, variable$_2$ = number$_2$,
   &END

Note that the &INPUT must be preceded and followed by one blank space. The variable names are given in the right-hand column of the input format. The variable list may be carried over onto another card, but all data on subsequent cards must precede &END.

The values for XNIN and XNOUT may not be changed by namelist. These variables are not included in the list.

If the number of hub segments is to be changed by namelist, the variable JHUB must be put in integer form, i.e., it must be followed immediately by a comma. This is mentioned because JHUB is a decimal input in the basic deck.

10.2.3 Mass Addition Under NAMELIST

Three additional variables are available under the NAMELIST option to allow the user to simulate the addition of a concentrated mass at a specified spanwise and chordwise location.

The three subscripted variables are ISEG, ADMASS, DAHPCA.

ISEG(I) = number of the segment at which the mass is added.

ADMASS(I) = the amount of mass added (lbm)

DAHPCA(I) = distance of the added mass ahead of the pitch change axis (inch).

The subscript within the brackets is the serial number for the mass addition. For example:

```
 &INPUT   ISEG(1) = 18, ADMASS(1) = 3.0, DAHPCA(1) = -0.9,
          ISEG(2) = 22, ADMASS(2) =-5.0, DAHPCA(2) =  0.5,
 &END
```

means the user wants to add 3 pounds in segment 18, 0.9 inch behind the PCA, and remove 5 pounds from segment 22 at a point 0.5 inch ahead of the PCA. 99 modifications are possible; hence the maximum subscript is 99 (i.e., ISEG(99));

It should be noted that this change takes place in the NAMELIST option only and leaves the basic deck permanently changed, i.e., these three new NAMELIST variables make cumulative changes to the deck, and the user should keep track of the changes. In the above example, if the next NAMELIST change reads

```
 &INPUT   ISEG(1) = 18, ADMASS(1) = -3.0, DAHPCA(1) = -0.9,
          & END
```

then the 3 pound mass, added in Segment 18 previously, is now removed. In the same NAMELIST case, many serialized changes can pertain to a single segment itself. Even if only one of the three variables (ISEG, ADMASS, or DAHPCA) is changed, all three should be redefined in a serialized fashion.

The program redefines the values of WTPL (weight per unit length), RC (distance of the segment cg behind the PCA), and EYEC (the chordwise mass moment of inertia about the cg, per unit span) for the segment defined by ISEG. Because RC and EYEC are also modified instead of just WTPL, the effects of mass addition on the blade torsional mode shape are expected to be well represented.

10.3 DNAMO5 OUTPUT

DNAMO5 output consists of printed listings, punched cards and CALCOMP plots, as requested by the user (on CARD 2).

The user should request program DNAM05 on the Service Request Card, unless plots were specified, in which case DNAM05P must be requested. A salmon-colored Off-Line Processing Request card must also be submitted with the deck, specifying CALCOMP plots on 401-A paper.

The frequency plots show natural frequency versus RPM. Uncoupled frequencies are plotted as solid lines, with the Southwell coefficients printed to the right of the lines. The coupled frequencies are plotted as open symbols.

The printout consists of

(1) a page with the contents of CARD 1 printed repeatedly

(2) a listing of the remainder of the input deck

(3) four pages showing the input and default values used

(4) pages tabulating and plotting the coupled mode shapes found by the analysis

(5) a summary of the coupled mode shape frequencies

If CALCOMP plots were requested, a summary of the uncoupled frequencies is printed.

10.4 ROTOR-INDUCED VELOCITY DISTRIBUTION TABLE GENERATOR, PROGRAM AR9102

Computer program AR9102 has been developed to generate non-uniform rotor-induced velocity distribution (RIVD) tables for C81. The program utilizes the simplified free-trailing wake analysis of Crimi (Reference 11).

The basic assumptions inherent in the analysis are:

1. The rotor blades are replaced by single lifting line vortices with strengths varying harmonically with azimuth position.

2. The wake is represented by individual free vortices trailing from the tip of each blade bound vortex.

3. Trailing root vortices and shed vortices are omitted.

4. The effects of viscosity and compressibility are neglected.

The total fluid velocity at an arbitrary point is expressed by the Biot-Savart law given in vector form as

---

[11] Crimi, Peter, THEORETICAL PREDICTION OF THE FLOW IN THE WAKE OF A HELICOPTER ROTOR, Cornell Aeronautical Laboratory Report No. BB-1994-5-1 and -2, New York, September 1965.

$$\vec{V}(\vec{r}_p) = - \frac{1}{4} \pi \int \frac{\Gamma \ (\vec{r}) \ \vec{r}_1 \ \times \ d\vec{r}}{r_1^3} + \vec{V} \tag{1}$$

where the integral extends over all vortex elements in the flow. Equation (1) is employed to calculate the velocity at each element of the trailing vortex so that the wake distribution may be determined.

The analysis begins by calculating a helical wake shape (assuming uniform inflow) and strength from given vehicle parameters and flight conditions. The bound vortex strength is approximated assuming the circulation is equal to the maximum value of an elliptical spanwise distribution and that blade lift is constant about the azimuth,

$$\frac{\Gamma_m}{\Omega R^2} = \frac{8L(1 - 2\mu \ \sin \psi)}{\rho \pi b \Omega^2 R^4} \tag{2}$$

Once the blade vertex strength is known, the trailing wake strength at any point is simply given by the circulation about the blade when it generates that point in the wake.

Observe that Equation (1) is indeterminate when the distance between adjacent points on the vortex (r_1) approaches zero. Therefore, to obtain self-induced wake distortions, the vortex representation includes a finite core of rotational fluid. Since the velocity induced by the core at a point depends on the curvature of the core through that point, a circular arc is fitted through the point in question and two adjacent points.

The trailing vortex geometry is shown in Figure 84. If it is assumed that vorticity varies linearly and the core radii are small with respect to vortex radius of curvature, the self-induced velocity is given by

$$\begin{aligned} V_{s_i} = \frac{1}{8\pi R} \Bigg\{ & \Gamma_{i-1} \left| \ln \frac{8R}{a_{i-1}} \tan \frac{\phi_{i-1}}{4} + \frac{1}{4} \right| \\ & + \Gamma_i \left| \ln \frac{8R}{a_i} \tan \frac{\phi_i}{4} + \frac{1}{4} \right| \Bigg\} \end{aligned} \tag{3}$$

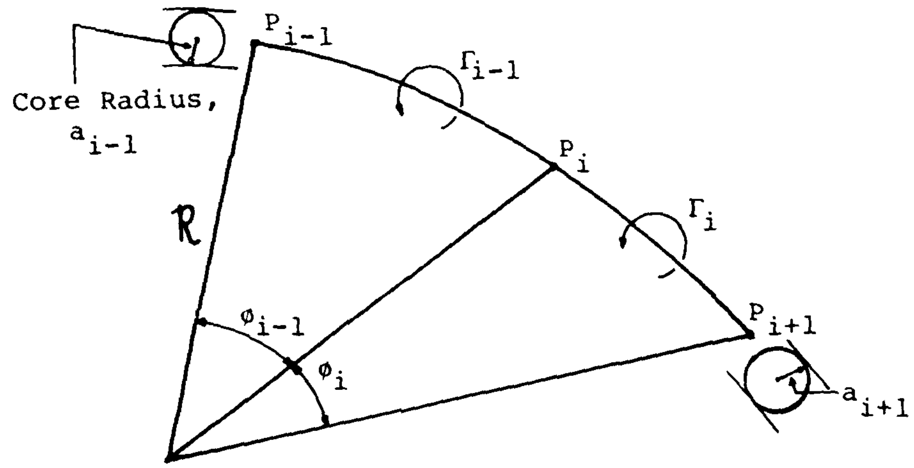


Figure 84. Trailing Vortex Geometry in AR9102.

The core radius, a, (immediately after rollup) is determined from energy considerations and has been found to be relatively insensitive to azimuth position for various flight conditions. Thus, a constant value based on percent rotor radius (default equals 5 percent) is assigned to the first element trailing the blade. Further downstream, however, vortex stretching and vortex enlargement or "bursting" due to blade-vortex interaction significantly affect the core size. Hence, the volume of core fluid is assumed constant, yielding a relation fixing the radii in terms of vortex length.

Each point on the trailing wake is convected by the surrounding fluid at the local velocity determined by Equations (1) and (3). Thus, given its initial position, the location of a point at any instant is specified by the displacement relationship

$$\vec{r}(t) = \vec{r}(t_o) + \int_{t_o}^{t} \vec{V}[r(\tau)] \; d\tau \tag{4}$$

The free wake geometry is obtained by applying Equation (4) to all points in the flow. Once the wake shape has been determined, the velocity field about the rotor at all nonwake points is calculated using Equation (1).

The wake analysis requires solution of Equation (4) where the integrand is defined by Equation (2), resulting in a nonlinear integral equation. The solution is obtained by a digital computer program that requires stepwise and interpolative approximations of the continuous functions. For example, the line integral along each tip vortex assumes that the vortex contains small rectilinear segments of constant circulation strength having initial lengths equal to the arc length of the blade tip swept through finite azimuth increments. Also, the time integration defining segment endpoint displacement is performed assuming the velocity remains constant over a time interval corresponding to the azimuth increment size.

Inputs to the computer program fall into three general categories: (1) inputs describing rotor and flight conditions, (2) inputs controlling degree of accuracy, and (3) inputs controlling various options and program logic. Using these inputs, the tip vortex locations and the velocity field about the rotor are determined by the wake model. The velocity components are normalized by either the computed value or an input value of the average induced velocity over the entire rotor disk. The normalized z-component of velocity can then be harmonically

analyzed to yield rotor-induced velocity distribution tables compatible with C81.

10.5 INPUT FORMAT FOR AR9102

CARDS 1-3 (20A4)

Alphanumeric title cards

CARD 4 (8A4)

Alphanumeric title card - punched out with table

CARD 5 (7F10.0)

BATA
(1) Number of blades (ft)
(2) Radius, R (in.)
(3) Chord
(4) Currently unused
(5) rpm
(6) Density ratio
(7) Currently unused

CARD 6 (7F10.0)

(8) Number of radial segments (default = 20)
(9) Azimuth increment (default = 10) (deg)
(10) Vortex core radius, a_v (default = 0.05) (%R)
(11) Vortex bursting factor, K_B, used as $K_B a_v$. Default value is a function of airspeed, as shown in Figure 85. Input K_B = 1.0 for no bursting
(12) Asymmetric blade loading, percent circulation of Blade 1 (default = 1.0)
(13) Currently unused
(14) Set equal to 1.0 to read optional CARD B, otherwise to 0.0 - use only if the harmonic coefficients are to be nondimensionalized on an input average induced velocity instead of the one internally computed

CARD 7 (7F10.0)

(15) Number of advance ratios
(16) Number of inflow ratios or wake plane angles of attack
(17) Program control variable, JGO

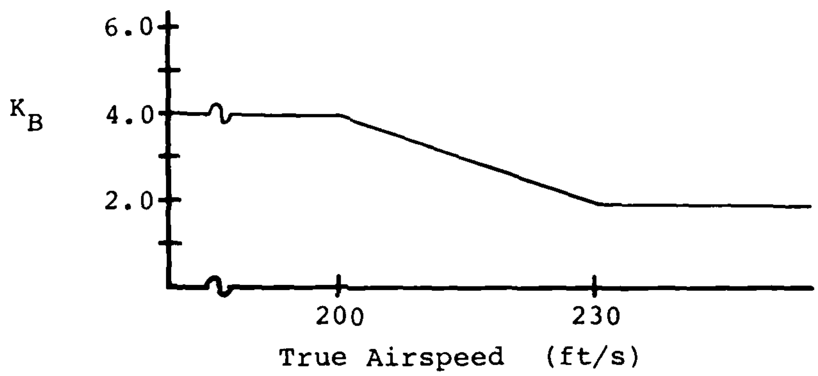


Figure 85. Default Vortex Bursting Factor in AR9102.

JGO = 0.0 generate RIVD table at constant inflow ratio (λ) dependent on first set of λ's calculated

= 1.0 same as JGO = 0 except λ's are input on additional CARDs C

= 2.0 input wake plane angles of attack, α_{WP}, for each λ and μ combination, on optional CARD D

= 3.0 RIVD tables at constant α_{WP}'s based on $\alpha_{WP_{min}}$ and $\alpha_{WP_{max}}$

= 4.0 RIVD tables at constant α_{WP}'s; input up to 10 α_{WP}'s to be used on optional CARD E

(18) Number of radial segments for output - read optional CARDs A if greater than 0.

(19)
(20) Currently unused
(21)

CARD 8 (7F10.0)

(22) Printed output control

= 0.0	prints induced velocities (+ down) and harmonics as used in RIVD tables
= 1.0	same as 0.0, plus vortex locations
= 2.0	same as 1.0, plus all velocities
= 3.0	same as 0.0, plus all velocities

(23) NPUNC Punch control

<10	no punched output
>10	punches out RIVD tables, NPUNC/10 times

(24) Maximum harmonic to be punched must be ≤ 9 (default = 6)

(25)
(26) Currently unused
(27)
(28)

CARD 9 (7F10.0)

(29)	Minimum resultant force	(lb)
(30)	Maximum resultant force	(lb)
(31)	Minimum airspeed	(KTAS)
(32)	Wake plane angle of attack at minimum airspeed-positive if resultant force inclined aft from perpendicular to wind	(deg)
(33)	Maximum airspeed	(KTAS)
(34)	Wake plane angle of attack at maximum airspeed	(deg)
(35)	Currently unused	

CARD 10 Currently unused

OPTIONAL CARDS - must be read in this order.

CARDs A Read only if BATA(18) > 0 (7F10.0)

Read the desired output radius distribution. Distribution must be root-to-tip. Three cards must be read even if BATA(18) $\leq$ 14.

CARDs B Read only if BATA (14) = 1.0 (7F10.0)

Read in up to 14 average induced velocities (computed by C81, for example) for each μ - positive down. <u>Must</u> read two cards for each μ. (ft/sec)

CARDs C Read only if BATA(17) = 1.0 (7F10.0)

Read desired λ's
<u>Must</u> read two cards

CARDs D Read only if BATA(17) = 2.0 (10F7.0)

Read α_{WP}'s for each λ (deg)
<u>Must</u> read one card for each μ.

CARDs E Read only if BATA(17) = 4.0

Read α_{WP}'s - same α_{WP}'s used for all μ's (deg)
<u>Must</u> read two cards

10.6 AR9102 USER NOTES

This program is normally used by setting BATA(17) = JGO = 3.0, setting the minimum and maximum resultant forces equal, and sweeping on μ and α_{WP}. There will be BATA(15) advance ratios, evenly distributed between the airspeeds of BATA(31) and BATA(33), and BATA(16) wake plane angles of attack for each advance ratio, evenly distributed between BATA(32) and BATA (34).

The average induced velocity computed by this program, VITV, differs from that computed by C81 subroutine VIND, which is also calculated by AR9102 and printed out as VINC81. This latter quantity is based on zero hub extent and no tip loss. Since VIND uses an empirical expression for the average induced velocity, the difference between its v_i and that computed by AR9102 is not surprising.

If BATA(18) $\neq$ 0, the program expects a desired radius distribution to be input, on OPTIONAL CARDs A. All three cards must be input, and the radius distribution may be input in any units, as it is internally nondimensionalized by the BATA(18)th radius input. The RIVD table punched under this option will have values of the induced velocity harmonics at the radii specified on CARDs A.

The punched output begins with a card-image of CARD 4 and each set of coefficients begins with a header card giving the advance ratio, inflow ratio, and wake plane angle of attack for that set. These header cards must be sorted out and an average induced velocity table created before the RIVD table is input to C81.

10.7 DATA FOR FUSELAGE AERODYNAMIC EQUATION INPUTS

When wind tunnel data are available, the digital computer program AN9101 can be used to reduce the data to the AGAP80 fuselage aerodynamic equation input format. The program was written in the PL/1 computer language. The input formats were chosen so that either fixed or floating point numbers may be input for any numeric data. It is not necessary to right-justify fixed point inputs.

The input data to the program consists of two cards of identifying comments and program logic variables and up to 300 data points of force and moment wind tunnel data. Each data point is input on one card and includes data point identification and the values of the pitch and yaw angles and the six force and moment values at those angles.

AN9101 is not an integral part of AGAP80. AN9101 only prepares data for input to AGAP80.

10.8 INPUT FORMAT FOR AN9101

Card 1

Col 1 - 70	Alphanumeric identifying comments
Col 71 - 80	SC, Scale Correction factor

Card 2

Col 1 - 70	Alphanumeric identifying comments
Col 71 - 75	NPTs, Number of cards (data points) in the following data set
Col 76 - 80	IO, Output selector switch ($\neq$ 1 print only, = 1 print and punch)

Card 3 through (NPTS + 2)

Col 1 - 5	The test (or run) number, or other numeric identification	
Col 6 - 11	Pitch angle	(deg)
Col 12 - 17	Yaw angle	(deg)
Col 18 - 25	Lift/(Dynamic Pressure)	(ft^2)
Col 26 - 33	Drag/(Dynamic Pressure)	(ft^2)
Col 34 - 41	Pitching Moment/(Dynamic Pressure)	(ft^3)
Col 42 - 49	Side Force/(Dynamic Pressure)	(ft^2)
Col 50 - 57	Rolling Moment/(Dynamic Pressure)	(ft^3)
Col 58 - 65	Yawing Moment/(Dynamic Pressure)	(ft^3)
Col 76 - 77	Sequence number of test point in data run, or other numeric identification	

Card NPTS + 3

Col 1 - 10	CODE

10.9 USER'S GUIDE TO AN9101 INPUT FORMAT

This program performs least-squared-error curve fits of wind tunnel force and moment data in order to determine the inputs to the Nominal Angle Fuselage Force and Moment Equations of the Rotorcraft Flight Simulation Computer Program AGAP80.

Card 1

The alphanumeric identifying comments are the first line of the printed output and, if punched ouput is selected, the first card of the punched output.

SC is the ratio of the desired scale of the output data to the scale of the input data; e.g., if full-scale data (scale = 1) are desired and the input data are from a 1/8 scale model where the data are still in model scale, then SC = 1(1/8) = 8. If the input data have already been converted to full scale, then SC = 1. If SC is deleted, or zero, the program sets SC = 1.

Card 2

The alphanumeric identifying comments are the second line of the printed output and, if punched output is selected, the second card of the punched output.

NPTS is the number of data points. It is equal to the number of cards in the data set which follow Card 2. The value of NPTS must be less than or equal to 300.

The value of IO determines the type of output from the program

IO $\neq$ 1 Only printed (on-line) output is to be provided.

IO = 1 In addition to the printed output, the coefficients calculated are punched on cards in the format required for Cards 131 through 13C of AGAP80, the Rotorcraft Flight Simulation Program.

Card 3 through (NPTS + 2)

The input CODE specified the type of data which follows:

CODE = 0 All new data follows; a new Card 1 follows this card.

CODE = 1 Data points are to be added to the data previously computed; a new Card 2 follows (Card 1 is deleted); NPTS on the new Card 2 is only the number of data points (cards) added to the data set, not the new total number of points in the set.

If CODE $\neq$ 0 or $\neq$ 1, the program assumes all data has been processed and the run is terminated.

10.10 OUTPUT GUIDE FOR AN9101

The user may select printed output only or printed and punched output. The printed output includes the coefficients of the fitted equations and comparison of the calculated and input data points. If punched output is selected in addition to the printed output, fourteen cards are punched. The first two cards contain the identifying comments from AN9101 Cards 1 and 2. The remaining twelve cards contain all the coefficients of the Fuselage Aerodynamic Equations in the sequence and format required for AGAP80, i.e., Cards 131 through 13C of the Fuselage Aerodynamic Equation Group. The data are fitted to the following equations:

Lift (L) and Pitching Moment (M)

$$
\begin{aligned}
L \text{ or } M = {} & C_{00} + C_{10} \sin \Psi_w + C_{20} \sin^2 \Psi_w \\
& +[C_{01} + C_{11} \sin \Psi_w + C_{21} \sin^2 \Psi_w] \sin (2\theta_w) \\
& +[C_{02} + C_{12} \sin \Psi_w] \sin^2 (2\theta_w) \\
& + C_{03} \sin^3 (2\theta_w)
\end{aligned}
$$

Drag (D)

$$
\begin{aligned}
D = {} & C_{00} + C_{10} \sin \Psi_w + C_{20} \sin^2 \Psi_w \\
& + [C_{01} + C_{11} \sin \Psi_w + C_{21} \sin^2 \Psi_w] \sin \theta_w \\
& + [C_{02} + C_{12} \sin \Psi_w] \sin^2 \theta_w + C_{03} \sin^3 \theta_w
\end{aligned}
$$

Side Force (Y), Rolling Moment (l), and Yawing Moment (N)

$$
\begin{aligned}
Y, l, \text{ or } N = {} & C_{00} + C_{10} \sin \theta_w + C_{20} \sin^2 \theta_w + C_{30} \sin^3 \theta_w \\
& + [C_{01} + C_{11} \sin \theta_w + C_{12} \sin^2 \theta_w] \sin(2\Psi_w) \\
& + [C_{02} + C_{12} \sin \theta_w] \sin^2 (2\Psi_w) \\
& + [C_{03} + C_{13} \sin\theta_w] \sin^3 (2\Psi_w)
\end{aligned}
$$

where θ_w = wind tunnel pitch angle

Ψ_w = wind tunnel yaw angle

C_{ij} = coefficients of equations

In the output data the coefficients, C_{ij}, are identified by the subscript, ij. The coefficients are printed out in "non-dimensional" and "dimensional" form. "Nondimensional" indicates that the coefficients are in units of ft^2 or ft^3, which are the units of C_{ij} in the above equations. "Dimensional" indicates that the coefficients are in units of ft^2 or ft^3 per degree to the appropriate power. The "dimensional" coefficients are those that would be used if the above equations were redefined for small angles; e.g., sin $\Psi_w \sim \Psi_w$, $\sin^2(2\theta_w) \sim 4(\theta_w)^2$, and θ_w and Ψ_w were defined to be in degrees. The "dimensional" coefficients are the inputs to AGAP80. Initialization routines in AGAP80 convert the coefficients to their "nondimensional" values prior to using them in calculations. The sequence number of the coefficient in the AGAP80 YFS array is given at the far right, e.g., for lift data, C_{00} is input to YFS(1).

Following the coefficient data is a tabulation of the input and calculated data. The first five columns are the wind tunnel input data:

RUN	=	Wind tunnel run number
PT	=	Number of data point in the run
PITCH	=	Pitch angle, deg
YAW	=	Yaw angle, deg
INPUT	=	Force or moment (corrected to full scale), ft^2 or ft^3

The next three columns are calculated data:

CALCULATION	=	Value of force or moment calculated using the appropriate equation and coefficients
DELTA	=	Input value minus calculated value (INPUT-CALCULATION)
REL-DEL	=	Delta divided by input value (DELTA/INPUT)

At the end of these data are two parameters useful in judging the quality of the curve fit:

SUM OF ABS (ERRORS)/POINTS = (Σ DELTA)/NPTS

RMS ERROR/POINTS = (Σ(DELTA)^2)/NPTS

A printout of the inputs to AGAP80 in the format of AGAP80 follows the parameters.

See Figure 86 for a sample printout from AN9101.

PROGRAM AS312A
CURVE FIT ANALYSIS OF WIND TUNNEL DATA
USING METHOD OF LEAST-SQUARED ERRORS

MODEL 206 TEST 294 FUSELAGE W/SKID GEAR RUNS 210 THRU 214
FINAL CHECK CASES

DRAG DATA

COEFFICIENTS OF EQUATION

SUB-SCRIPT	NON-DIMENSIONAL	DIMENSIONAL	AGAJ73 INPUT
00	2.10 FT**2	2.099379 FT**2/DEG**0	XFS(29)
10	-0.66 FT**2	-0.011553 FT**2/DEG**1	XFS(35)
20	67.67 FT**2	0.020613 FT**2/DEG**2	XFS(36)
01	-2.92 FT**2	-0.050906 FT**2/DEG**1	XFS(37)
11	2.02 FT**2	0.000615 FT**2/DEG**2	XFS(38)
21	0.84 FT**2	0.000004 FT**2/DEG**3	XFS(39)
02	29.90 FT**2	0.009108 FT**2/DEG**2	XFS(40)
12	-1.95 FT**2	-0.000010 FT**2/DEG**3	XFS(41)
03	-10.99 FT**2	-0.000058 FT**2/DEG**3	XFS(42)

INPUT DATA AND CALCULATIONS

RUN/PT		PITCH	YAW	INPUT	CALCULATION	DELTA	REL-DEL
210	1	-11.76	0.00	3.8100	4.0289	-0.219	-0.05746
210	2	-10.46	-16.01	9.3000	9.1174	0.183	0.01964
210	3	-10.53	-12.01	6.6600	6.8494	-0.189	-0.02844
210	4	-10.45	-8.01	4.9300	5.1408	-0.211	-0.04276
210	5	-10.69	-6.01	4.5200	4.5950	-0.075	-0.01660
210	6	-10.76	-4.00	4.2800	4.1633	0.117	0.02726
210	7	[illegible]	[illegible]	4.0600	4.1110	-0.051	-0.01256
[illegible]				[illegible]	4.0404	-0.230	-0.06048

Figure 86. Sample Output from Program AN9101.

(Data for Runs 211 through 213 omitted).

		18.08	-14.01				
214	6	18.33	-11.99	6.6800			
214	7	18.49	-10.00	5.9600	5.9174		
214	8	18.60	-8.01	5.2300	5.2036	0.026	0.00505
214	9	18.69	-6.01	4.6800	4.6407	0.039	0.00840
214	10	18.73	-4.01	4.3200	4.2292	0.091	0.02103
214	11	18.75	-2.01	4.1100	3.9773	0.133	0.03230
214	12	18.76	0.00	4.0630	3.8883	0.172	0.04229
214	13	18.76	1.99	4.1500	3.9628	0.187	0.04512
214	14	18.75	4.01	4.3000	4.2034	0.097	0.02247
214	15	18.75	5.99	4.5300	4.6036	-0.074	-0.01625
214	16	18.75	8.01	5.0700	5.1754	-0.105	-0.02079
214	17	18.67	10.01	5.7500	5.8842	-0.134	-0.02335
214	18	18.49	12.01	6.5300	6.7271	-0.197	-0.03019
214	19	18.35	13.99	7.6000	7.7187	-0.119	-0.01562
214	20	18.19	15.99	8.7100	8.8619	-0.152	-0.01744
214	21	18.05	17.99	9.9700	10.1497	-0.180	-0.01803
214	22	18.06	20.02	11.6700	11.6261	0.044	0.00376
214	23	18.78	-0.01	4.0600	3.8926	0.167	0.04123

SUM OF ABS(ERRORS)/POINTS= 0.2304
RMS ERROR/POINTS= 0.0267

INPUTS FOR AGAJ73
2.0994 -0.011553AGAJ73 25
0.020613 -0.050906 0.000615 0.000004 0.009108 -0.000010 -0.000058AGAJ73 26

Figure 86. Concluded.

END

11. REFERENCES

1. McLarty, T. T., et al., ROTORCRAFT FLIGHT SIMULATION WITH COUPLED ROTOR AEROELASTIC STABILITY ANALYSIS, Volumes I - III, Bell Helicopter Textron, USAAMRDL Technical Reports 76-41A, 76-41B and 76-41C, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, May 1977, AD A042462, AD A042908, AD A042907.

2. Philbrick, R. D., and Eubanks, A. L., OPERATIONAL LOADS SURVEY - DATA MANAGEMENT SYSTEM, Volumes I and II, USARTL TR 78-52A and 78-52B, Applied Technology Laboratory, U.S. Army Research and Technology Laboratories, Fort Eustis, Virginia, 1979, AD A065129, AD A065270.

3. Bisplinghoff, Raymond L., Ashley, Holt, and Halfman, Robert L., AEROELASTICITY, Addison-Wesley Publishing Company, Reading, Massachusetts, 1955.

4. Young, A. D., THE AERODYNAMIC CHARACTERISTICS OF FLAPS, British Aeronautical Research Council RM No. 2622, February 1947 (also printed as R.A.E. Report Aero. 2185, August 1947).

5. McCormick, B.W., Jr., AERODYNAMICS OF V/STOL FLIGHT, Academic Press, New York, 1967.

6. Etkin, Bernard, DYNAMICS OF FLIGHT, New York, John Wiley and Sons, Inc., 1959.

7. USAF STABILITY AND CONTROL DATCOM, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, February 1972.

8. Perkins, C. D., and Hage, R. E., AIRPLANE PERFORMANCE STABILITY AND CONTROL, John Wiley and Sons, Inc., New York, 1967.

9. Dommasch, D. O., Sherby, S. S., and Conolly, T. F., AIRPLANE AERODYNAMICS, Pitman Publishing Corporation, New York, 1967.

10. Silverstein, A., and Katzoff, S., DESIGN CHARTS FOR PREDICTING DOWNWASH ANGLE AND WAKE CHARACTERISTICS BEHIND PLAIN AND FLAPPED WINGS, NACA Report No. 648, 1939.

11. Crimi, P., THEORETICAL PREDICTION OF THE FLOW IN THE WAKE OF A HELICOPTER ROTOR, Cornell Aeronautical Laboratory Report No. BB-1994-5-1 and -2, New York, September 1965.